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### Growing Up.

The entrance of the American Electrochemical Society at its recent meeting upon its second decade of activity is not, as it happens, an event of merely the usual birthday significance. The Society is becoming "grown up." The increase in membership is not only proceeding with a steadiness which, coming after the first flush of exuberant enthusiasm, marks a continual growth of interest, but it also has most desirable qualitative features. The phenomena of the Society's internal growth are, however, even more striking. Not a few members who attended the interesting colloquium on electrical conductance must have been struck by the extreme difference in the atmosphere of the meeting as compared with that prevailing some years ago. One recalls the rather ill-informed and sometimes contemptuous treatment which used to be meted out by many members to every reference to the ionic theory, which was at that date, within obvious limitations, generally accepted and used to the limit for what it was worth in all societies dealing with the same and allied subjects. What a contrast to the intelligent interest manifested in the Boston symposium on conductance, which turned out to be in large measure a discussion from many points of view on the electronic hypothesis.

It is not well to push parallelism too far, but we cannot help feeling that the explanation is to be sought in the evolution of the electrochemical industry itself. As is usually the case, this industry was based in its inception upon the pioneering work of men who were often brilliant technicians first and scientists second; but the growth and development of the industry have placed it, as again is normally the case, in the hands of men who are not only technicians, but scientists. This change has not been without its influence upon the personnel of the Society, and if we mistake not, it is this change that is responsible for the encouraging phenomenon noted above. It cannot be contended that the electronic hypothesis is likely to have any important direct bearing upon the progress of the electrochemical industry; and it may therefore be taken as granted that it is not a species of "enlightened selfishness" that leads a society, essentially technical in its nature, into these fields of hypothesis. The matter may rather be taken as an indication that the men who today are active in the field of technical electrochemistry are largely men of scientific training who keep bright their interest in pure science, not only for what it will bring but for what it is.

It is this happy interplay of the pure and technical sides of the subject that made the Boston meeting notable. There are some who will have noted how characteristic of this meeting it was that one of the most important papers dealt with the measurement of temperatures in the silicon carbide furnace; and that the discussion on thermal conductances brought out a complete acknowledgment of the other fellow's point of view

and of the value of the other fellow's work from the advocates both of the empirical and theoretical methods of attacking problems in this field. How different again from those past meetings in which the advocates of these complementary methods in other fields steadily refused to recognize that the other man had any point of view at all!

Certainly the Electrochemical Society is becoming grown up. Perhaps it will now discard the pink pinafore of its lusty childhood.

### Laboratories for Metallurgical Education.

It is a striking coincidence that two prominent schools of mines, one in the United States and one in Europe, should adopt at practically the same time a radical departure in methods of instructing students in the practice and art of metallurgy. We refer to the erection and equipment of large, commercial-size ore dressing and metallurgical laboratories at the Colorado School of Mines, and at the Royal School of Mines in London. The latter has been completed and formally handed over to the college governors, while the former is partly equipped and soon will be ready for use.

Since opinion is divided among technical educators as to the advisability of "large-scale" or "small-scale" laboratories for metallurgical instruction, we are frankly interested in the future of these two notable examples of the former type, and especially in the one at Golden. It is a pioneer experiment, and as such will have many problems to solve. Fortunately, those who are responsible for the innovation at Golden have long realized the magnitude of their undertaking, and have endeavored to develop in a satisfactory manner the varied relations which the plant will sustain to education and commercial ore testing.

On another page in this issue, Dr. Alderson, president of the Colorado School of Mines, has outlined these relations as far as they have been developed. Perhaps it will be necessary, with accumulated experience, to modify and adjust these relations; but in addition to the educational features, it is expected that the plan will render valuable aid to engineers and alumni of the school who may wish to undertake more prolonged and detailed investigation than would be possible with private facilities. In this way, the commercial features of the laboratory will not encroach upon private enterprise, but will supplement it, and will stimulate research and investigation which otherwise might not be undertaken. This, probably, is the largest problem, and in the solution of it lies, in a large measure, the success of the venture.

### The Work of the Bureau of Mines.

It is becoming more settled that the relation of the federal Bureau of Mines to the metallurgical industry is to take a broad general form, as outlined in our editorial columns last February. The early agitation for government "testing plants" is dying out for the simple reason that the idea was ill-founded and without merit. On the other hand, both the Director of the Bureau and his associates who are directly charged with metallurgical investigations, have taken pains to familiarize themselves with the general situation, and have developed a tentative plan of action, subject to such modifications as further familiarity and experience shall direct.

Several points seem to be quite clearly settled. The government will not encroach upon private enterprise nor start investigations in those branches of metallurgy which are being so wonderfully and rapidly developed by individual members of the profession. This at once disposes of the bogey of government assay offices and testing plants. On the contrary, the Bureau will make investigations in those fields which are not well developed, and which even may be unattractive to private enterprise. (Whether the inherent danger of this is realized, is not yet clear. Spending money for research is generally unattractive and may become more so by the action of the Bureau. This would be a real calamity.) The work of the Bureau is intended to be that of the pioneer, laboring far afield, and perhaps engaging in researches which promise no immediate return, and the results of which may be negative. There are problems which even our largest companies do not undertake to solve, because the prospect of gaining commercial advantage is very uncertain, or because the idea seems too academic or even chimerical. And yet, if there is a possibility that the research is worthy of consideration on account of the knowledge and fundamental data to be obtained, the Bureau would be justified in undertaking it. In short, the Bureau is to keep its investigations well in advance of those likely to be undertaken privately. By fostering such work and showing its value, the Bureau hopes soon to gain the co-operation of private investigators and even hopes to stimulate research in those places where too little attention now is paid to it.

The recovery of by-products and the development of uses for them is to be made a special field for the Bureau's activities. Sulphur and arsenic at present constitute the two most important substances in this class, which can be recovered in large quantities, provided more extensive use can be found for them. Another line of work which may be undertaken is a study of the physics of ore slime, and the elucidation of principles which can be applied to slime concentration, which is admittedly the weakest point in ore dressing.

In the actual conduct of its work, it is expected that the Bureau will be enabled to make its researches at plants already established and working on a large scale. There will be a double advantage in this. First, the Government will not have to spend large sums of money in erecting plants for purely experimental purposes, in which the cost of research could not be offset by the profit which accrues to a going concern. Second, the results of experiments conducted on a large scale in a commercial plant will be of greater value than corresponding results obtained from laboratory work, for the latter sometimes are misleading when applied to operations on a large scale. While these advantages are evident, the danger is also evident that the work undertaken by the Bureau might be carried out in the interest of individual plants rather than in the interest of the whole public whose money is being spent, after all.

Clearly the problems involved in the organization of the work of the Bureau of Mines are not easy to solve. Their solution and the ultimate direction of the work must be left to the Director and his associates, who must be guided not only by their own wisdom, but also by the crystallized opinion of the better informed class of scientific and technical investigators.

### The Titanic Disaster.

In the shadow of one of the greatest disasters of all time it may seem irreverent to speak of the sinking of the Titanic as furnishing suggestions in engineering, but there are phases of this terrible catastrophe which it seems particularly appropriate to mention in these columns.

One phase is the role which wireless telegraphy played in the disaster. Dreadful as was the disaster, it would have been more dreadful and more complete without wireless telegraphy. Thus again the work of the pure physicist has proven of eminent practical applicability. In view of the progress that has been made in this field, it seems remarkable that physicists should not yet have discovered a method of detecting the presence of icebergs from a distance with certainty. It seems even more remarkable that in these days where recording thermoelectric pyrometers and recording electric resistance pyrometers are in daily use not only in chemical, metallurgical and engineering works, but in various industries and trades, like bakeries, breweries, etc., the finest ocean liner built without regard to expense should have adhered to the method of getting up a pail of water every two hours and measuring its temperature. It reads like an anachronism.

There is another and more general thought suggested by the Titanic disaster. The progress in all branches of engineering is rapidly towards larger and larger undertakings, and the larger the structure the greater should be the unit strength of the material. Recent experience has shown that a steel passenger car can leave the track traveling at a speed of sixty miles an hour and dissipate its kinetic energy sliding over hard ground, without serious deformation. The Titanic, at the lesser speed of between 26 and 27 miles an hour, carried but one-fifth as much kinetic energy per unit of weight and was terribly deformed by a glancing blow upon ice, which may not even have absorbed all its energy of motion. Without entering at all upon the engineering principles involved in car and vessel construction, it is perfectly obvious that it is very much more difficult to make the larger structure safe. A small sphere may be made of thin gage sheet steel and resist deformation if projected at a great speed against a hard object, but a solid steel sphere can be conceived so large that it would crumble of its own weight.

As size increases the unit strength of material must increase, otherwise the useful function performed by the structure will decrease until it vanishes entirely and any larger structure would be unable even to preserve itself. A cable in a deep mine is a familiar illustration of this principle; for a given unit strength it can be made so long that it will break of its own weight. As engineering works increase in size their demand will be for steel of greater and greater unit strength, and steel metallurgy is building merely for the near future, for a demand which is certain to prove large, when it endeavors to produce, within commercial limits of cost, a steel of much greater unit strength than the steel now commonly employed.

### Government Regulation of Industry.

In 1887 the original Interstate Commerce Act was passed. Ten years later the Supreme Court handed down its decision in the Maximum Rate Case, holding that the Commission had

no authority to prescribe a maximum rate. Theretofore, the Commission had interpreted its authority under the law that rates should be just and reasonable as warranting it in prescribing that a given rate was unreasonable "to the extent that it exceeded" a rate which it named. Under the decision of 1897 a railroad could kill time almost indefinitely by making new rates graded downward by merely sensible gradations. Fifteen years later we find in practice a complete system of rate making by the Interstate Commerce Commission. It is easy to recall that when the first step was taken, only a quarter century ago, towards Federal regulation of railroads, the chief ground from the popular viewpoint which furnished the authority was that the railroads had been given the right of eminent domain. Today that fact is rarely considered at all as a basis for the federal authority.

There are those who stand aghast at the idea that the federal government should regulate the production and sale, as well as the transportation, of goods in interstate commerce, yet it is easier to conceive now in the light of experience, of such regulation being instituted, than it was fifteen years ago to conceive the present system of railroad rate regulation by the Interstate Commerce Commission, and it is well to reflect upon the wonderfully rapid progress this commission has made, as a means of conditioning our minds for the contemplation of federal regulation of the production and sale of commodities.

The work of the Interstate Commerce Commission is not a work accomplished. The work has only begun. What has occurred is that the commission has been delegated the authority, and the authority has been recognized by the institutions which are to be regulated. It is said by the experts, for instance, that in the decision in the Pittsburgh-Lake coal rate, rendered only this year, occurs the first instance of the Commission taking into serious consideration the cost of performing the service, in fixing a rate. Obviously, however, this is fundamental, and before the Commission lies practically the entire task of establishing a system of rates which are proportionate to the cost of the respective services, to replace a system in which the cost of performing the service only remotely enters in the case of any individual rate. For this task, of course, there is requisite the physical valuation of the railroads which the Commission has long requested means to make, and which is certain to be made within a very few years.

In the light of these developments the possibility of avoiding similar control over industries appears chimerical in the opinion of many, and it is emphasized that this is a definite constructive work, not to be purchased ready made at a bargain counter, but to be prosecuted step by step as in any engineering undertaking. But just because it is, sight should not be lost of the fundamental question whether regulation of the production and sale of commodities is possible at all in a free country. No individual, no corporation, however big, can do it; this fact has been settled by experience. And the fact that the federal government is so much bigger does not prove in any way that it can perform regulation of production and sales of commodities without changing the whole foundation of economic life. As we have pointed out, it is likely that government regulation will come some day and experience will then show how it works. It is a pity that this question can only be decided by actual experiment.



### Bureau of Standards Analyzed Samples.

The Bureau of Standards, Washington, D. C., is now ready to distribute certain special steels, as follows: No. 30, chrome-vanadium; No. 32, chrome-nickel; No. 33, nickel. The fee for these steels will be \$2.50 each. A renewal of No. 19, acid open-hearth steel, 0.2 carbon, will probably be ready before this notice appears in print. Until printed certificates can be had, the above steels will be issued with provisional certificates without details of analyses or description of methods.

### The Iron and Steel Market.

Steel mills being well sold up, and having reached the point of being able to operate at full capacity, with a few small exceptions, the market on finished steel products was taken in hand early in April and a progressive stiffening in prices has occurred. The leaders in the upward movement have been bars, plates and shapes. Bars were first advanced to 1.15 cents, and after the middle of the month to 1.20 cents. Plates and shapes first stiffened up to 1.15 cents, then advanced to 1.20 cents and finally in the closing days of the month advanced to 1.25 cents. To the keen observer the movement partook more or less of the nature of a "controlled market" though there is no definite price agreement in the trade. There remains a disposition on the part of the different mills to co-operate. This disposition is not strong enough to prevent price cutting when there is not enough business to go around, but when mills are well filled with business it requires no great sacrifice to advance prices.

Effective April 11 the American Sheet & Tin Plate Company advanced its prices about \$2 a ton, establishing minimum quotations of 1.40 cents on blue annealed sheets, 10 gage, 1.95 cents on black sheets, 28 gage, and 3.00 cents on galvanized sheets, 28 gage. While the independents did not adopt the new minimum quotations at once there has been a disposition to withdraw the lowest quotations and the whole market is measurably firmer in this branch of the trade.

Taking the finished steel trade as a whole, buyers have contracted to purchase more material than they can use and producers have contracted to furnish more material than they can make, up to July 1. Contracts are not seriously regarded, as a rule, and amount to little more than options. The present price advances mean very little as to the average prices which will be realized on shipments to be made during the next two or three months, but they furnish a basis for higher priced contracts when these contracts expire. The question is really chiefly as to whether the mills will be strict in cancelling unspecified tonnages July 1. It is a question of unspecified tonnages, not of unshipped tonnages. The prospect is that they will be strict, as the market is in a relatively strong condition.

The steel trade as a whole is running at the rate of more than 90 per cent. of capacity. Some of the mills in the east are not operating full, and in some branches of the finished steel trade in the central west there is not full operation, but the situation as regards mill operations is entirely satisfactory. It is the best in about two years.

Specifications on contracts are naturally good when open market prices have been advanced above the price level in contracts, but specifications are not phenomenally good, and the probability is that jobbers and manufacturing consumers will specify for considerably less material in the third quarter than they are doing in the second quarter. This change would be likely to leave a gap later on, and weaken the market, but there are positive assertions made that the railroads will become heavy buyers within the next two months, and even a moderate increase in railroad buying would add greatly to the strength of the situation. It may be concluded that the steel industry is assured of practically full operation until after the November election.

### Pig Iron.

There has been a fairly heavy buying movement in nearly all districts. While purchases are not unusually large, considering the normal requirements of the individual purchasers, there is more buying ahead, betokening confidence in the situation and a general tendency of prices to advance. Steel making irons did not advance, except for an advance of 50 cents in basic iron in the East. In the Central West, the chief business was the purchase by the Republic Iron & Steel Company from valley furnaces of 40,000 tons of basic at \$13, furnace, and an equal tonnage of Bessemer at \$14.25, furnace. Quotations are as follows: Foundry iron, \$10.50 to \$10.75 for prompt and \$10.75 to \$11 for forward, Birmingham; \$15 to \$15.25, Philadelphia, \$13.25, valley; \$14.25 to \$14.50, Chicago; basic, \$15, Philadelphia; \$13, valley; Bessemer, \$14.25, valley.

### Steel.

The month of April saw the withdrawal of nearly all the mills as sellers of billets and sheet bars, as specifications had been very heavy and the requirements of their own finishing departments had also increased. Finishing mills are well covered, as a rule, to July 1 and the market is not active, though with a very strong undertone. Billets may be quoted at \$20 and sheet bars at \$21, Pittsburgh, but these quotations are largely nominal. Rods are \$25, Pittsburgh.

### Finished Material.

As the market became strong Chicago disappeared again as a separate basing point for bars, plates and shapes. In 1909, and again recently, the idea became prevalent that on account of the increased production of the Chicago district it had become a separate basing point, but on the appearance of a stronger market the Pittsburgh basis renewed its control over Chicago. Competition can hardly be eliminated if separate basing points are in existence. Before the Chicago basis disappeared in April, bars, plates and shapes were quoted in Chicago at 15 cents per 100 lb. over the Pittsburgh basis, the actual freight being 18 cents. Chicago prices are now 18 cents above Pittsburgh prices.

Current price, f. o. b. Pittsburgh, unless otherwise stated:

Rails, standard sections, 1.25 cents for Bessemer, 1.34 cents for open-hearth, f. o. b. mill, except Colorado.

Plates, tank quality, 1.25 cents.

Shapes, 1.25 cents.

Steel bars, 1.20 cents.

Iron bars, 1.25 cents, Pittsburgh; 1.27½ to 1.30 cents, Philadelphia, 1.15 to 1.20 cents, Chicago.

Sheets: blue annealed, 10 gage, 1.40 cents; black, 28 gage, 1.90 to 1.95 cents; galvanized, 28 gage, 2.95 to 3.00 cents; painted corrugated roofing, \$1.35 per square; galvanized, \$2.50 per square; according to the American Sheet & Tin Plate Company's new practice, inaugurated April 18, five cents per 100 lb. over the price of flat sheets for corrugating, and an additional extra for painting of five cents per square for gages 12-18, 10 cents for gages 19-24 and 15 cents for gages 25-28.

### The Non-Ferrous Metal Market

The anticipation of fifteen-cent copper has been realized and exceeded, and a large volume of business has been transacted at a figure approaching sixteen cents. Most of this business was for foreign delivery, and much of it was with speculative interests. Lead has been erratic, and spelter sluggish with little demand.

**Copper.**—The feature of this market has been the lack of demand or even inquiry for Lake copper, practically the bulk of the business being done in electrolytic. The latest quotations are 15¾ to 16 cents for Lake, and 15.70 to 15.80 for electrolytic.

**Lead.**—The St. Louis Market reached a parity with New York owing to the concentration of speculative business at the former market. Later, however, the St. Louis market returned to more nearly normal conditions. The last quotations are: St. Louis, 4.12½ to 4.15 cents; New York, 4.20 cents.



**Tin.**—A fair domestic business has been transacted for future delivery at slightly lower prices than those ruling abroad. Both foreign and domestic markets have been without feature. April tin was quoted at New York at 43 cents.

**Spelter.**—This market has been decidedly dull, with small tonnages moving for April, May and June deliveries. The tension in the spelter market is less than it was a short time ago. The last quotations are 6.35 to 6.55 cents, St. Louis, according to delivery, and 6.50 to 6.70 cents, New York.

**Other Metals.**—There has been a fair business in aluminum, but prices are firm at 20 to 20½ cents New York. Antimony remains steady at 6½ to 8 cents for various brands, and business is fair. The demand for quicksilver is good, but there has been a wide range in prices. The last quotations are \$42 to \$44 per flask of 75 lb. at New York, and \$42.50 for domestic and \$40 for export at San Francisco.

### The Western Metallurgical Field.

#### Mason Valley Copper Smelter.

Reports of the operation of this new plant at Thompson, Nev., indicate that the one blast furnace in commission is far exceeding its rated capacity. Two furnaces of 400 tons capacity each were a part of the original plan of the smelter, but thus far only one has been in commission. Early in April this furnace was treating about 700 tons per day, and it is expected that this record will be maintained. The installation of a sintering plant has aided materially in raising the capacity of the furnace, for the sintered product is in almost ideal condition for furnace charge. In addition to handling the ores from the Mason Valley and Nevada-Douglas mines, the company is receiving ores from other smaller companies in the vicinity. Twelve companies are on the custom list.

#### Smelting and Agriculture in California.

It appears that the Shasta County Farmers' Protective Association is determined to keep on the trail of offending smelters and cause them to live up to the unfortunate terms of the court decree under which they can operate, and which provides that the gas issuing from the stack shall contain no SO<sub>2</sub>, no solids, and shall not exceed 0.75 per cent SO<sub>2</sub>. The farmers have recently considered proceeding against the Mammoth plant of the United States Smelting Company, which recently expended several hundred thousand dollars in equipping the smelter with a bag house. The present complaint is to the effect that the bag house does not prevent damage.

In view of the unreasonable insistence of the farmers it is probable that the smelters may combine and ask permission to operate under an agreement to reimburse the farmers for damages. A commission of three men, one appointed by the smelters, a second by the farmers and the third by the court, may be organized to act as final arbiter in settling the amount of damage done. This arrangement is said to be under consideration by the United States company and the First National Copper Company, the latter having been out of commission for some months.

Further report is to the effect that the First National company is considering the installation of a new process to eliminate the sulphur from the fumes. Judging from the description obtainable, this refers to the thiogen process, which consists in reducing the SO<sub>2</sub> to sulphur by the reducing action of crude oil. This process is known to be in experimental operation at Campo Seco, Cal., under the direction of the inventor, Mr. S. W. Young.

#### Colorado.

The mining industry in this state, which has not been flourishing for the past few years, shows signs of improvement. Manufacturing and supply houses are reporting increased activity, and engineers have more work in prospect than for some time

past. At Leadville, the local smelter has five furnaces in blast and is treating more ore than for two years past. This is regarded as an excellent indication of prosperity in the Leadville district, where smelting ores predominate. It is expected that when the roads are in better condition the tonnage offered to the smelter will be still greater.

Those properties which are producing zinc are working to full capacity in view of the excellent condition of the spelter market. At some properties which could not mill their ore during the winter there has been steady development work in the mines, and every preparation has been made for continuous milling as soon as the winter season is over.

It is reported that the Suffolk, which is the largest group of mines in the Ophir district in southwestern Colorado, is to be equipped with a cyanide plant this spring. There is now a stamp-amalgamation-concentration mill on the property, which has been in operation during the winter. Cyanide experiments have been carried on for some months with such successful results that the mill will be remodeled to include treatment by cyanidation. It is possible that amalgamation and concentration will be dispensed with, and the entire output of the mine cyanided. This is a distinct advance over the old method and will result in financial benefit to the company. The amalgamation recovery has not been high, and the cost of shipping and smelting concentrate has been so great that the net return to the company has not been as much as it will be under the cyaniding system. It is expected that the new plant will be in operation this summer.

#### Potash in Borax Lake, California.

A potash deposit of apparently great importance has been discovered at Borax, or Searles Lake, in the northwestern corner of San Bernardino County, California, and the value and extent of the discovery are now being investigated by the Bureau of Soils and the Geological Survey. The lake or playa in which the discovery was made is the last remaining pocket of a once much greater lake which has almost dried up, and in the central depression of which is a large body of crystalline salts known to consist of common salt, sulphate and carbonate of soda and borax. The salt body is saturated with brine, and interested persons stimulated by the government search for potash recently secured an analysis of an old sample of this brine. The result being significant, the lake was visited by representatives of the government bureaus, who took brine samples from six wells distributed over the salt flat.

Analyses of these samples have been made at the laboratory of the Mackay School of Mines, Reno, Nev. They show an average of 6.78 per cent potassium oxide in solution. The average salinity of the brine is 43.82 grams of solids per hundred cubic centimeters. Comparison of the results indicate that the brines are nearly uniform throughout the flat. The probable importance of this deposit is due to the occurrence of the potassium salts in soluble form in a natural saturated brine, and under climatic and other conditions favorable to its separation and recovery by solar evaporation.

Existing data give reasonable assurance that the brine-saturated salt body is at least 60 ft. thick and covers an area of at least 11 sq. miles. Assuming the salt body to contain 25 per cent by volume of the brine, the total amount of potassium oxide is estimated at over 4,000,000 short tons. This estimate is believed to be very conservative, and the available tonnage may well be expected to exceed 10,000,000 tons, which would supply this country, at present rate of demand, for thirty years. At any rate, it appears that this locality constitutes a very important source of potash in a form that probably is readily available for commercial use. Methods of separating potash from brines are now under investigation by the Bureau of Soils.

#### Company Reports.

**The Old Dominion Copper Mining & Smelting Company,** Arizona, has issued its annual report covering the calendar year

1911, from which we take the following interesting data. The average grade of ore mined and treated was as follows:

	1911	1910
	Cu per cent.	Cu per cent.
Average smelting ore .....	7.75	7.85
Average concentrating ore .....	3.50	3.49

The concentrating operations are indicated in the following table:

	1911	1910
	Dry tons.	Dry tons.
	Cu percent.	Cu percent.
Old Dominion ore ..	78,059	86,060
Custom ore .....	62,171	19,339
	4.61	4.18

The cost of concentrating is shown below:

	1911	1910
	\$	\$
	1.012	0.975
Dry tons concentrated .....	140,230	105,399

During the year there was purchased and installed a set of 36 x 16 rolls and a 6-ft. Evans-Waddell Chilean mill, the total cost of which was \$7,238, which amounted to \$0.052 per ton of ore concentrated.

A comparison of smelting costs for 1911 with those of the previous year shows a material reduction.

	1911	1910
	\$	\$
	2,568	2,926
Tons of ore charge smelted.....	231,603	239,162

Included in the above cost for 1911 is an expenditure of \$16,359.50 for installing a mixing system, amounting to \$0.07 per ton new charge smelted. The lower cost in 1911 is due mainly to the ore-mixing system, which was installed in 1910 and further perfected in 1911. It has done much to solve one of the most important problems, and has improved metallurgy and reduced costs.

The cost of converting per ton of fine copper was as follows:

	1911	1910
	\$	\$
	8.26	9.68

Pounds fine copper produced.... 24,482,019 27,742,332

Power is produced in a battery of eight Sterling water-tube boilers, with a total rating of 2340 boiler hp, against the average requirement for the year of 1500 hp. The cost per hp-year was as follows: 1911, \$83.77; 1910, \$96.18. With the new contract for fuel oil, which became effective last October, power costs should be reduced 20 per cent.

#### United States Smelting, Refining & Mining Company.—

An item in the sixth annual report of this company speaks eloquently of the difficulty of finding mining properties which are worthy the consideration of a large company. During 1911 921 properties were considered; 749 were declined without examination; 144 were partly examined; 28 were completely examined, and one was purchased.

#### Camp Bird.

The report to the effect that new discoveries of importance had been made in the Camp Bird mine, Ouray County, Col., has been confirmed by the London office of the company. The last annual report of this company acknowledged the depletion of the ore reserves, and intimated that the mine and mill would be operated only a part of this year unless new and unexpected discoveries were made. Apparently the unexpected has happened, and it is reported that the mine will have a further lease of life. This remarkably good fortune comes to a company which has been a leader in good mine management and good metallurgy.

## CORRESPONDENCE.

### The Lead and Zinc Tariff.

To the Editor of *Metallurgical and Chemical Engineer*:

Sir:—In your article upon lead and zinc tariff under date of March, 1912, some reference was made as to the sentiment expressed by mining men in Spokane regarding the entry of

lead and zinc ores from Canada, which might lead the reader to infer that we are in favor of the free entry of such ores from Canada.

This, however, is not the case. As you know the production of lead and zinc scarcely meets the local demand in Canada and the cost of production is in excess of that in the United States, and for these reasons resolutions were passed some time ago favoring the entry into the United States of lead and zinc ores and their products upon a reciprocal basis.

As yet there is very little manufacturing done in Canada, the products of these metals being imported from the United States almost wholly.

There now seems little hope of any reciprocal relations with Canada, inasmuch as they are now advocating a tariff upon both metals.

Spokane, Wash.

L. K. ARMSTRONG.

### Chemical Formulae.

To the Editor of *Metallurgical and Chemical Engineering*:

Sir: The writer has long been impressed with the unsatisfactoriness of chemical equations as found in the ordinary text-book, and for this reason recently made a brief investigation into the matter. Ten of the most popular works were selected and examined with reference to the reaction between lead nitrate and potassium chromate. Eight of the books gave the reaction as follows:



No comment was made, and the reader was left to infer that this is the only reaction to expect under ordinary conditions. Book number nine gave two salts,  $\text{PbCrO}_4$  and  $\text{Pb}_2\text{CrO}_6$ . Book number ten gave these two, and  $(\text{PbO})_2(\text{CrO}_4)_2$  in addition; the conditions under which each of these salts would be formed were also given.

Now what are the facts. Those who have to do with the chemistry of lead have been trying for years to discover the conditions under which a definite chromate of lead could be produced. Several methods of analysis have been published based on the precipitation of chromate of lead, but the conditions to be observed are many, and a slight variation from any one of them is fatal to accuracy. For these reasons the great majority of chemists have never adopted a chromate method for estimating lead.

Further investigation of the text-books showed important differences among the various authors in their manner of writing a great many reactions. Yet each gave his own idea without comment, leaving the reader to infer that no doubt exists as to its accuracy.

The writing of a good book is a difficult task and perfection is not to be expected; but why not reduce the number of imperfections to a minimum. Would it not be better, in the case of lead chromate, for example, to say that a basic chromate is produced, and that its composition varies with conditions not easily controlled. A reaction could be given, but always with an explanation to the effect that a different reaction might occur if the concentration, temperature, or some other condition were changed.

It would not be a poor idea for every man who writes a book, first to read Boyle's "Skeptical Chymist," and particularly that part wherein Boyle pleads with "those who are addicted to chymistry" to make no statements of which they are not sure. The application of this rule would materially reduce the volume of writing, but would add enough to its quality to more than compensate for the loss in quantity.

"The prophet that hath a dream, let him tell a dream; and he that hath the law, let him speak the law faithfully."

Golden, Colo.

JOHN C. BAILAR.

**Swedish Water Power Development.**—It is estimated that the water power in Sweden increased in 1911 about 80,000 hp, aggregating at the close of the year 640,000 hp.

## The Action of Electro-Mechanical Forces on the Bath of Induction Furnaces.

BY MAGNUS UNGER.

The electro-mechanical forces that act upon the bath of induction furnaces are of considerable magnitude, and as a thorough understanding of the character is of importance from a designing as well as from an operating standpoint, a study of the subject may be of interest.

For a better analysis of these forces we may divide them in two classes:

1. The mutual attraction of current carrying elements within the bath, similar to the attraction of two parallel conductors carrying current in the same direction.
2. The repelling force between the bath (secondary winding) and the primary winding, similar to the repelling force between two parallel conductors carrying current in opposite direction.

### Pinch Effect.

The first mentioned force has previously been fully explained by Dr. E. F. Northrup and Dr. Carl Hering and is generally referred to as the "pinch phenomenon" or "pinch effect." I would particularly call attention to Dr. Hering's paper on the subject "The Working Limit in Electric Furnaces Due to the

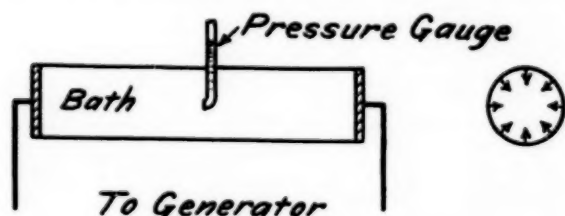


FIG. 1.—MEASUREMENT OF PINCH EFFECT.

Pinch Phenomena" (Trans. American Electro-Chemical Soc., Vol. XV, 1909; this journal, Vol. VII, p. 266, 1909).

The attractive force acting upon each current carrying element is directed so that the effect is to contract or squeeze the bath. The pressure, which is highest at the center of the bath, may be measured by suitable means as indicated in Fig. 1. Dr. Northrup gives the following formula for the pressure at the center of a bath having circular cross section:

$$P = \frac{I^2}{97,854 S}$$

$P$  is the pressure in grams per sq. cm.

$I$  is the current in amperes.

$S$  is the cross-section in sq. cm.

Although this formula is strictly correct only for conductors of circular cross section, no great error is made in apply-

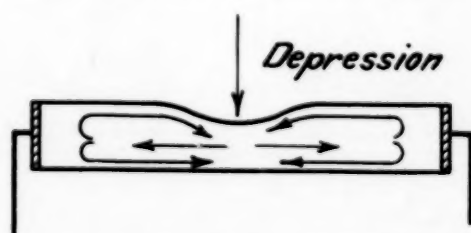


FIG. 2.—CIRCULATION OF BATH.

ing it to conductors of square section, and it can thus be used for practical conditions such as they exist in induction furnaces.

When current is sent through a liquid conductor of uniform section, the pinch effect will cause the liquid to be under a certain pressure, but there is no force to cause a circulation. If now for some reason or other the section of the conductor is reduced in some spot, as, for example, through a piece of float-

ing brick, the pressure at this place, as can be seen from the above formula, will increase. The pressure at the center of the reduced area is thus larger than that outside, the effect of which is that the liquid is squeezed out horizontally in both directions from the center of the reduced area. A circulation as indicated in Fig. 2 is then the result.

In observing the circulation on top of the bath, it gives one the impression as if the liquid were sucked in under the brick.

If the current is increased, this suction will also increase, and the level of the bath, where the original contraction was, will lower its level. As the current is further increased, a limit is reached when the liquid is squirted out from the center of the contracted area faster than it can return, and the result is a break in the circuit. If the liquid is sufficiently fluid, the circuit will continue to close and open some time until finally freezing occurs.

In the paper already referred to, a formula is developed by means of which the critical current values

for the pinch effect in a liquid conductor may be calculated approximately. It is shown that the deeper the bath and the higher the specific gravity of the liquid the larger is the critical current value.

It is evident that the pinch effect is inherent with induction furnaces. As it is impossible to maintain an absolutely uniform section of the bath even in the simple design where the crucible is annular, the pinch effect will cause circulation of the bath, and the compressing effect is, of course, present whether the section of the bath is uniform or not. From a metallurgical standpoint, these features, circulation and compression, are, of course, very valuable.

Experience has shown that the pinch phenomena does not cause any difficulties in the operation of large induction furnaces as used in the steel industry. In this case the currents used are far below the critical value. However, the pinch effect makes it impossible to operate furnaces having a bath of very low specific gravity or of very low specific resistance such as aluminum and copper.

### Centrifugal Effect.

The effect of the repelling force between the bath and the primary winding of an induction furnace resembles in many respects the effect that the centrifugal force caused by rotating the circular bath on its axis would have. It may therefore perhaps be proper to refer to this force as the "centrifugal force" and we may then also use the expression "centrifugal phenomenon" and "centrifugal effect."

In an interesting paper by Dr. C. P. Steinmetz on "Mechanical Forces in Magnetic Fields" (Trans. A. I. E. E., Vol. XXIX, 1910) the theory and calculation of forces between transformer windings are given. The same reasoning may be applied to induction furnaces when it is considered that an induction furnace is theoretically equivalent to a transformer with a short-circuited secondary.

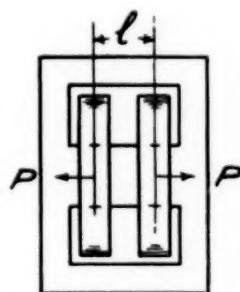


FIG. 3.—SHELL TRANSFORMER.

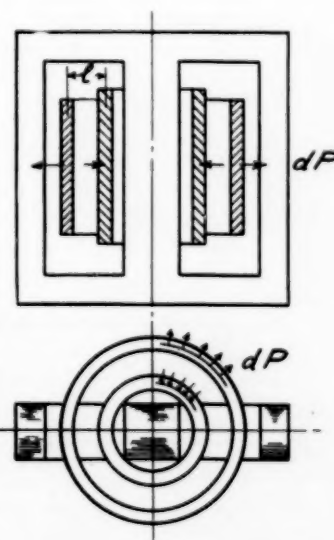


FIG. 4.—CORE TYPE OF TRANSFORMER.



Mechanical forces will appear where magnetic fields act on current carrying conductors, as between the primary and secondary coils of a transformer. These forces are proportional to the strength of the field and current. In case of transformers the field in question is the stray field, that is, the field that does not follow the core but passes between the primary

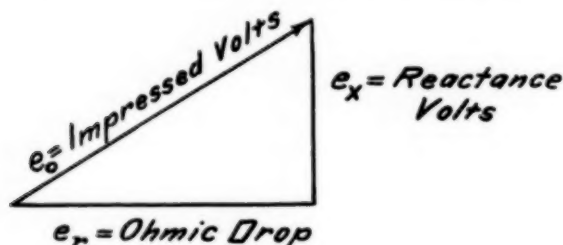


FIG. 5.—VECTOR DIAGRAM.

and secondary coils. If the secondary winding of a transformer is short-circuited and voltage is applied to the primary, no magnetic flux will pass through the secondary winding, provided that the voltage drop due to the ohmic resistance of the windings is so small that it can be neglected. In this case, therefore, the total flux passes between the primary and secondary coils. Theoretically the stray flux is caused by the reactance component of the impressed voltage. The total mechanical force which is then exerted on the winding as repulsion may be calculated from the formula:

$$P = \frac{8100 e_x i_o}{f l}$$

$P$  is the repulsion in grams.

$e_x$  is the reactance component of the primary voltage.

$i_o$  is the primary current.

$f$  is the frequency in cycles per second

$l$  is the distance in cm. between the coils plus half the thickness of each coil.

In transformers the voltage component due to the ohmic drop is usually so small that it can be neglected and in that case  $e_x = e_o$ , the impressed voltage. In induction furnaces the ohmic drop is not negligible, as the heating of the charge and the operation of the furnace is based on the secondary winding or bath having a high resistance. Referring to Fig. 5, it will be seen that  $e_x$  can easily be calculated if  $e_o$  and the primary power factor are given:

$$e_x = e_o \sqrt{1 - (\% P. F.)^2}$$

The formula for the repelling force as given above may be applied equally as well to the shell-type transformer as shown in Fig. 3 as to the core type shown in Fig. 4. In the former

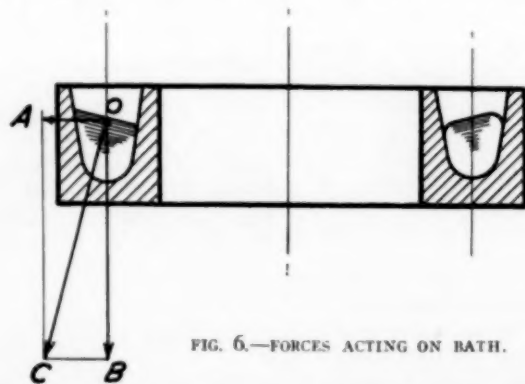


FIG. 6.—FORCES ACTING ON BATH.

construction there is actually a tendency to move the coils apart, while in the core type there is no such tendency provided that the coils are perfectly concentric. In the shell-type transformer the repelling forces on the individual current carrying conductors are all in the same direction and their algebraic sum

equals " $P$ " in the above formula. In core-type transformers these infinitesimal forces are not parallel, but are all directed radially from the center of the coils. The algebraic sum of these forces is, however, equal to " $P$ " in the above formula. In case of core-type transformers, therefore, the effect of the repelling force is to expand the outside and to contact the inside coil.

The repelling force acting upon the bath of a single-ring induction furnace is of the same nature as the force on the outside coil of a core-type transformer, that is, the centrifugal effect is present.

If we disregard the pinch phenomenon, it is then evident that two mechanical forces act upon each element of the bath, the gravity ( $OB$ ) and the centrifugal force ( $OA$ ) as shown in Fig. 6. The level of the bath must be perpendicular to the resultant force ( $OC$ ), that is, it will be inclined to the horizontal as shown.

As the pinch effect tends to make the cross section of the bath circular, we should expect that the section would be as

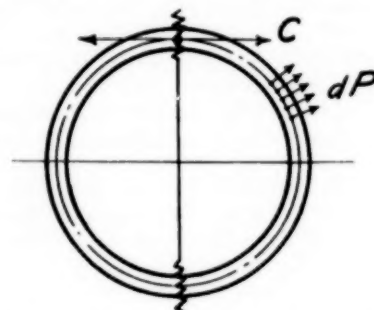
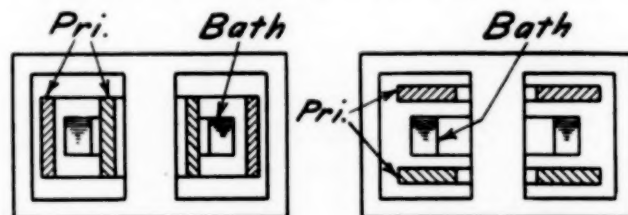


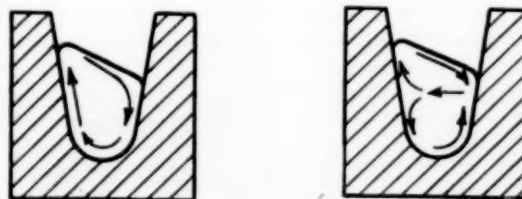
FIG. 7.—FORCES ACTING ON SOLID RING.



FIGS. 8 AND 9.—DIVISION OF PRIMARY WINDINGS IN SECTIONS.

shown on the right hand side of Fig. 6. This is also exactly what has been observed in induction furnaces. That the centrifugal force may be of considerable magnitude is proven by the fact that in a large Kjellin furnace when operating at full load the level of the bath is inclined about 30 deg. to the horizontal.

While the centrifugal force throws the liquid bath against the outer wall of the crucible, and thus tends to force out enclosed gases, there is no tendency to break the circuit. Such tendency is, however, present in case of a solid secondary ring such as



FIGS. 10 AND 11 CIRCULATION OF BATH.

is used in starting the furnace. The force (see Fig. 7) which tries to tear the ring apart can easily be calculated and is equal:

$$C = \frac{P}{2\pi}$$

With  $P$  obtained from the previous formula, the value of  $C$  will be given in grams.

While this force is far too small to break the ring at normal temperatures, it may be high enough to do so at higher temperatures when the tensile strength of the material in question gets low. Actual experience has shown that starting rings

may break open shortly before they get liquid, leaving an absolutely clear break such as is obtained when broken under ordinary tension. While this phenomenon may have been ascribed to the pinch effect, it is undoubtedly due to the centrifugal effect.

The centrifugal force causes a very marked circulation of the bath. This circulation takes place in planes at right angles to the direction of the bath and has been explained as follows:

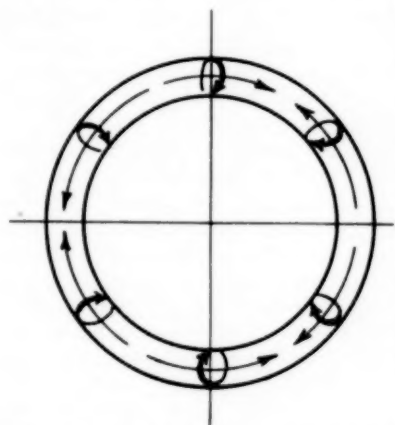


FIG. 12.—CIRCULATION IN SINGLE-RING KJELLIN FURNACE.

The metal at the surface of the bath has a tendency to cool and thus gets heavier than the interior metal. Due to the slanting level of the bath the heavier metal will sink down along the top of the bath and the inside wall of the crucible, thus setting up a circulation as indicated in Fig. 10.

It seems, however, that this circulation can be explained as caused directly by the centrifugal force as follows:

The repelling force between two current carrying conductors is stronger the shorter the distance between the conductors. The force on the current carrying elements along the inside wall of the crucible is therefore stronger than on those further out and the result is a circulation as indicated in Fig. 11.

The circulation caused by the centrifugal force may be so violent as to wear and seriously shorten the life of the crucible lining. This difficulty can, however, be avoided by using suitable designs, as the formulas available allow the operation of a furnace to be well determined.

From the previous discussion it is evident that by dividing up the primary winding in sections, as shown in Figs. 8 and 9, the effect of the centrifugal force may practically be eliminated, or by choosing other locations the centrifugal effect may be calculated to give a mild, desirable circulation of the bath. In this manner the trouble from breaking of the starting ring will also be reduced or fully overcome. This trouble may also be reduced by decreasing the power when the ring gets up to a high temperature.

The circulation is liable to be more pronounced in large furnaces, and to overcome this difficulty the furnaces designed by Frick and by Hiorth have sections of the primary winding located above and below the bath.

#### Combined Effect.

The pinch, as well as the centrifugal force, exerts a compressive effect upon the bath, and which is of great value in tend-

ing to free it from enclosed gases, and thus give a homogeneous product.

The circulation set up in the bath by the magnetic forces, as explained, is very desirable in order to obtain a uniform product.

The circulation in the bath of a single-ring Kjellin furnace is indicated in Fig. 12 and that of a single phase combined induction and resistance furnace (R & R type) is shown in Fig. 13.

### Steel?

By J. W. RICHARDS.

"Call a spade a spade"; but beware how you call it a *steel* spade!

We are getting nearer and nearer to an inevitable *impasse*, as to what is meant or what shall be meant when we say "steel." Let us briefly review the past and the present meanings of the word, in order that we may intelligently decide what its future, fixed and definite, meaning ought to be.

Thousands of years ago, Tubal Cain made iron directly from iron ore, and undoubtedly he or someone soon after him, left iron in the fire till it became carbonized to steel. The original product from the ore was soft wrought iron, not holding a cutting-edge long, and not capable of being hardened or tempered. The finer material made from soft iron could be hardened and tempered, and held a cutting-edge; from whence came the famed blades of Damascus and Toledo, the Ma'ay creese and the Saracen scimeter. Tradition says that the fine temper of the Damascus blades was due to the virtues of a famous spring in which the hardening was performed; the Japanese swordsmith put on a ceremonial robe when he tempered his Lord's sword, and the true Samurai parted with every earthly possession before suffering separation from his "honorable" weapon. Such sentimental, ornamental, fine, delicate, superlative stuff was the ancient steel, treasured by man and appreciated by the gods.

In the fifteenth century, comparatively recently in the history of siderurgical art, the "high furnaces" of Germany began turning out a new product, a fluid impure iron, so far removed in nature from iron or steel as to be considered at first a waste and undesirable material. It was fusible at a white heat, whereas no one had before melted iron or steel; it was hard, brittle, incapable of being hammered or forged, softened or tempered. This "Roheisen" was called by our forefathers "cast iron," because it was the first iron they had even seen cast, or capable of being cast. We know the material somewhat better than they, we know its characteristics to be due to 2.2 per cent or over of carbon content, and we know how to soften it somewhat when we want a cheap semi-malleable metal-casting. This material, however, the product of the blast furnace or a similar furnace, manufactured directly from iron ore, we call "pig iron," and when re-melted, "cast iron." There are no two opinions as to what this material is, what we call it, and what we ought to continue to call it.

Passing on, however, from the 15th century, we find Huntsman, in the 18th century, melting steel and making "cast steel," so called because it was the first appearance of fluid steel, cast into moulds, in the industry. It was very well and appropriately named; it had the identical qualities of the best steel which had never been fused, except that the fusion, if carefully done, left it improved in quality. Attempts were made to melt and cast soft wrought iron, but they did not then succeed. What they might have called the product, had they succeeded, it is useless to speculate upon.

Early in the 19th century considerable steel was made in the puddling furnace, the puddling operation being stopped before the stage of soft wrought iron had been reached. This cheap steel was variously called puddled-steel, wrought-steel, and later weld-steel. It was extinguished as a commercial product by the advent of Bessemer steel.

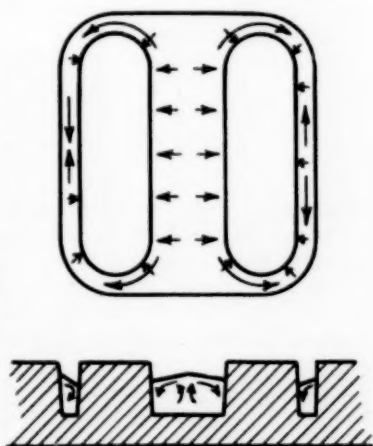


FIG. 13.—CIRCULATION IN ROECHLING-RODENHAUSER FURNACE.

In 1855 Bessemer discovered his cheap way of making steel, blowing cast-iron to melted soft iron, and then re-carburizing to the desired quality of steel. He did not make an ultimate product so low in carbon that it would not harden and temper, and therefore Bessemer steel took its place in commerce without raising any question of nomenclature; the product was simply cast fluid steel of the ordinary definition.

In 1862 the Siemens-Martin furnace came on the stage, producing a de-carburized molten material which was practically pure soft iron, but re-carburizing it to steel in the ordinary sense of the word as an ultimate product. Later, improvements in the re-carburizing and de-oxidizing material added made it possible to turn out a low-carbon product properly de-oxidized, and the open-hearth steel furnace then commenced to put on the market a new product, one never seen before in commerce, a low-carbon cast material resembling open-hearth steel in manufacture and uses excepting that it was not capable of being hardened and tempered. In fact, it soon found uses, such as for boiler plates, where hardening and tempering were no longer in question, but where strength and uniformity were the main *desiderata*. Then a merry war of nomenclature commenced. The manufacturers wanted to call it steel, because of the superior qualities associated with that name, and since they made it in the same furnace, from the same materials, in the same way, as ordinary carbon steel which did harden, they saw no impropriety in selling it as steel—soft steel, mild steel or dead-soft steel. The users, in general, accepted these terms. Objections were made by purists in classification, who pointed out that steel, as so far understood in the history of the art, must contain enough carbon to usefully harden and temper; "soft steel" did not answer these requirements, and therefore was not steel. The Germans recognized most clearly this violence to the old classification, and steadfastly and consistently refused to officially recognize the new product as steel; the German tariff laws refer to it as "flüss-eisen" or "flowed-iron," the English equivalent being "ingot iron."

After fifty years of discussion the commercial, scientific and even the official world has about settled upon calling this soft, cast material "steel," we may regard it as *fait accompli*, and accept what appears to be the inevitable. I believe there is no longer any protest against this, as practically everybody is now agreed. Let us put it down then, as ultimately settled, that the low-carbon product of the steel melting furnace, incapable of usefully hardening or tempering is and should continue to be called "steel."

Starting from this standpoint, what shall we now give as a scientific or accurate definition of steel? As the case now stands we have to make a hybrid definition, to fit an anomalous situation, *viz.*, steel is that form of usefully malleable iron which contains sufficient carbon to usefully harden and temper (old material steel, from the commencement of the industry), and also any usefully malleable product of the steel-melting furnace which may contain less carbon than this amount. We have here a definition which describes the facts, as to what is now called steel, but which refuses to fit into a scientific classification of iron and steel products.

In this dilemma, what are we to do? Let things go, says one, because the definition fits the facts; but this is simply leaving the matter in an unsatisfactory condition as far as man's instinct to arrange and classify is concerned. Make a new definition of steel, says another, call everything made in a steel-melting furnace steel, and cut out everything else. Now, here are two radical propositions, the first unsatisfactory to our rooted instincts of orderly classification, the second so unjust and arbitrary as to deserve a protest from every lover of fair-play and consistency.

It appears to me that the scope of the term steel has been gradually widening, and that in the future it will become still more comprehensive. If we adopt a principle of classification which narrows the scope of the term, we will not only be doing injustice but will be working against the tendency of the

times. It is therefore evident that the best principle of classification to adopt is that which broadens the term until it covers, as simply as possible, all that the term can properly be extended to cover.

Our former classification has broken down. We can no longer set up ability to harden and temper as the essential characteristic of steel. Neither should we set up the criterion of having been produced in the fluid state in a steel-melting furnace, thus barring out all steel of plastic origin—the historic steels. Furthermore, it is a false principle of classification to use the method of manufacture as a basis; the materials should be classified on properties ascertainable from the materials themselves, and in no manner on their past history.

At this point, the writer proposes that *malleability*, useful malleability, be made the criterion of classification; that all iron be divided into (1) the brittle, not usefully malleable material, cast iron, and (2) the usefully malleable material, steel. The classification is thus based upon a most valuable physical and commercial property which is readily ascertainable. It allows the term steel to include everything that is now known as steel, and, for the purposes of a proper and scientific classification, based on a physical property, includes in it one material not now called steel.

Wrought iron is not pure iron, but contains small quantities of carbon, phosphorus, sulphur, etc., with some intermingled slag. Dead-soft steel, of lowest carbon content producible in the steel melting furnaces, is of similar chemical composition, and nearly free from intermingled slag. The two materials have nearly identical physical properties and uses, one is often sold for the other, and one is often used indifferently for the other, *e. g.*, black plates for tin-plate. In a broad classification no violence is done by putting these two materials in the same large class. Call that class steel, and its intrinsic characteristic useful malleability, and the end in view is attained—a strictly scientific and practical classification, based on ascertainable properties.

I, therefore, propose that "Steel" be the generic name for all varieties of usefully malleable iron, and if doubt exists as to whether the material is usefully malleable, that the containing of less than 2.2 per cent of carbon be the supplementary criterion. The term would then include the following materials: Of plastic origin (welded together), wrought iron, puddled steel, blister steel, cemented bar, single-shear steel, double-shear steel; of fluid origin (cast from the fluid state) ingot iron, mites castings, dead-soft steel, mild steel, carbon steel, alloy steels.

The broad classification proposed would simply be:

COMMERCIAL IRON.	
Usefully malleable.	Not usefully malleable.
(Carbon under 2.2%)	(Carbon over 2.2%)
Steel.	Cast Iron.

The effect of altitude on roasting is mentioned by Pearse in Bulletin No. 90, I. M. M. He states that at an altitude of 13,000 ft., with 52 per cent oxygen in the atmosphere, the effect on Bruckner roasters was to reduce their capacity to about 33 per cent; in other words, about three times the number of Bruckner furnaces would have to be installed at the altitude given than would be necessary at sea level in order to supply a blast furnace of given capacity. At 15,000 ft., with 44.5 per cent oxygen in the atmosphere, the roasting value was reduced to about 25 per cent.

The introduction of the tube mill in metallurgy is credited by Henry Hanson in a paper read before the Canadian Mining Institute, to Dr. Ludwig Diehl, who was metallurgist for the London Hamburg Gold Recovery Company, and who made a success of the Hannan Brown mill in Australia. The first mill of this type was installed by Dr. Diehl at the Hannan Star Mine, Kalgoorlie, Western Australia. Since then the tube mill has found a place of increasing importance in the metallurgy of gold and silver ores.



## The Evaporative Capacity of Lead-Lined Copper Coils.

### A Record of Three Runs from Evaporation Practice with Some General Practical Conclusions on Evaporation.

By B. VIOLA, M. E.

Member American Society of Mechanical Engineers.

As I have mentioned in former articles, only lead coils are suitable as a heating surface for the evaporation of certain acids, since they are acid-proof to a certain extent. However, as they are not very strong mechanically, they do not last very long, they lose soon their original shape and finally become absolutely useless for the purpose for which they are intended.

To get a stronger and longer lasting heating surface, lead-lined copper coils may be used instead. They have proved very effective in practice. They last at least three times as long as pure hard-lead coils. The vacuum pan in this case is mostly a single-effect, of the construction shown in Figures 41 and 43 in one of my former articles (this journal, Vol. IX, page 349, July, 1911).

It would be a very hazardous thing to assume with positiveness in advance a certain value of the heat transmission coefficient for any heating coil, because it always depends on the

### First Run.

Thirteen thousand two hundred and eighty-five kgs. citric acid liquor at 8½ deg. B. and 43 deg. C. were concentrated to 32 deg. B. at an average boiling temperature of 145 deg. F. = 62.78 deg. C., as shown on recording chart Fig. 58, with a lead-lined copper-coil heating surface of 10.66 square meters, consisting of two lead-lined copper coils, 75 mm diameter of copper with 5 mm lead lining, so that the outside diameter is 85 millimeters, each coil being 20 meters long. Then according to formula (7) (this journal, January issue, 1912, page 32)  $W = 9631$  kgs. of water have to be evaporated.

This run was finished in 12 hours or 802.66 kgs. were evaporated per hour. This gives an evaporation of 75.3 kgs. per square meter an hour.

According to equations (2) and (6).

$$W = \frac{HC(t_2 - t_1)}{Q(t - t_0)} = 75.3$$

where

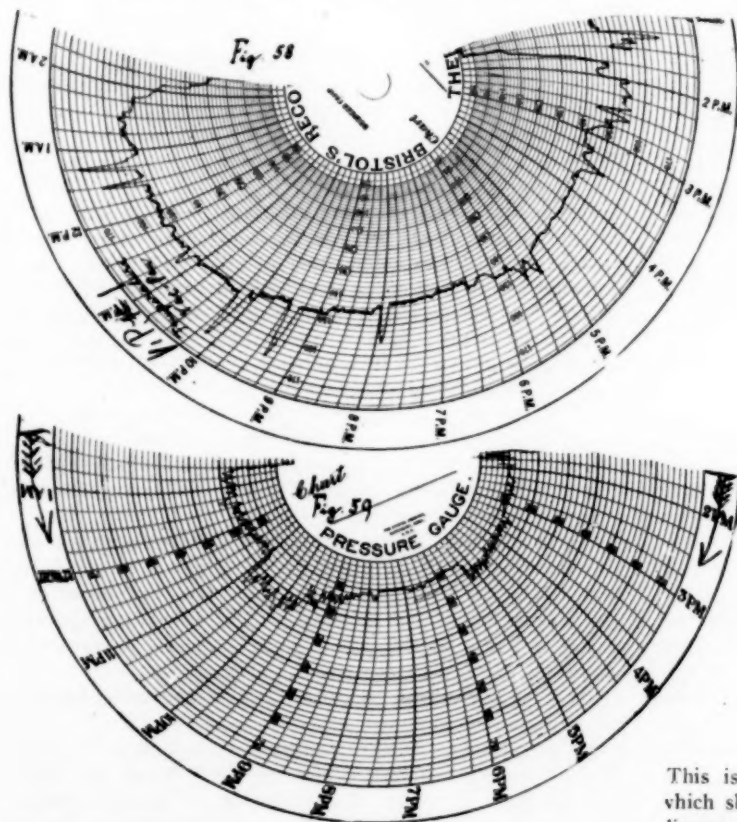
$H = 1$ .

$t_2 = 162.78$  deg. C. temperature of heating steam.

$t_1 = 62.78$  deg. C. temperature of boiling liquor.

$t_0 = 43.0$  deg. C. original temperature of liquor.

Hence  $C = 1107$  calories per square meter and hour. This is the coefficient of heat transmission corresponding to an



RECORD CHARTS OF FIRST RUN.

FIG. 58.—BOILING TEMPERATURE.

FIG. 59.—STEAM PRESSURE.

FIG. 60.—VACUUM.

hourly evaporation of 75.3 kgs. of water per square meter and hour under the conditions of the run.

The quantity of steam and the calories needed for the evaporation can be easily calculated from the equations (4) and (25) of the previous article quoted above.

It is very interesting and instructive to follow closely the conditions during the evaporation.

This is possible by means of reliable recording instruments which show the steam pressure, the boiler temperature of the liquor, the vacuum at which the evaporation is carried out, etc.

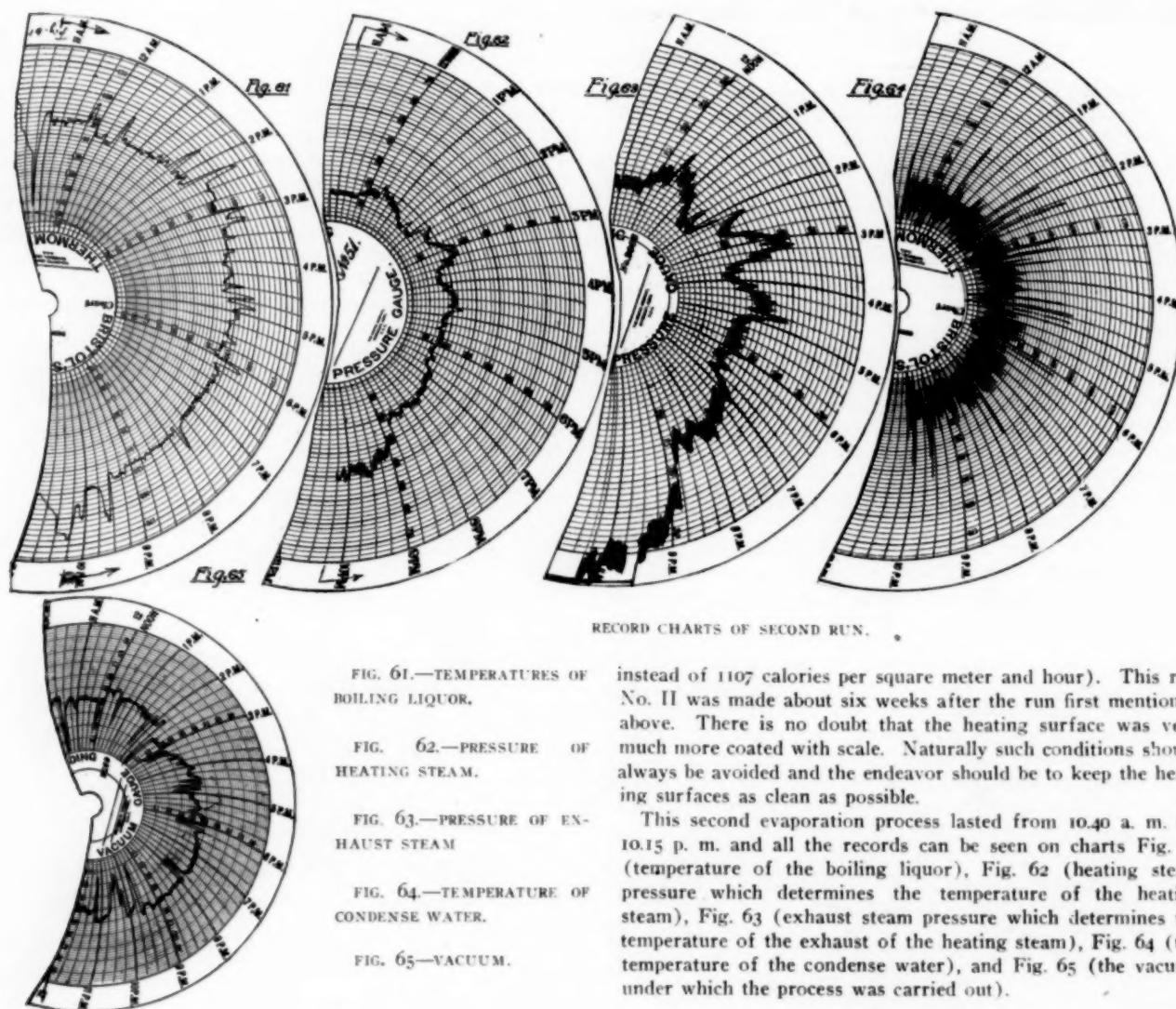
For the evaporating process under discussion running from 1.30 p. m. to 1.30 a. m., Fig. 59 shows the steam pressure (which determines directly its temperature). Fig. 58 shows the boiling temperature in the vacuum pan during the same period, and Fig. 60 the vacuum under which the process was carried out.

It is very astonishing to see on the temperature chart 58 the many variations of the boiling temperatures. However, when we compare it with Fig. 60 (the vacuum chart), we find the explanation.

This single effect was a part of a group of vacuum pans, all connected to the same vacuum pump. Now, for instance, at 5.15, 9.30, 10.15 p. m., etc., the vacuum went down because some of the other vacuum pans were freshly charged and at this time

thickness of the liquor, on the diameter and the length of the heating coil, and on the effective temperature of the heating steam.

Even when using the same apparatus different results are obtained with the same heating coil, if there are any differences in the condition of the scales on the surface, and these are hard to control. Further we know from the readings of our measuring instruments that we do not get exactly the same records all the time. Therefore, when we speak of the heat transmission coefficient, we always mean approximate or mean values. Such variations as occur in practice I will illustrate by a few records of runs, which will clearly prove the correctness of my assertions.



RECORD CHARTS OF SECOND RUN.

FIG. 61.—TEMPERATURES OF BOILING LIQUOR.

FIG. 62.—PRESSURE OF HEATING STEAM.

FIG. 63.—PRESSURE OF EXHAUST STEAM.

FIG. 64.—TEMPERATURE OF CONDENSE WATER.

FIG. 65.—VACUUM.

all the air had to be removed from these pans. The vacuum pump, being thus suddenly overloaded, was not able to keep up the high vacuum so that at such times the vacuum fell off a few inches until all the air was drawn off. This is a direct demonstration of the fact that the lower the vacuum the higher the boiling temperature and a direct explanation of the reason why in a multiple effect the first body has the lowest vacuum and the highest boiling temperature and reversely the last body the highest vacuum and lowest boiling point.

#### Second Run.

In a later run with the same single effect and the same two lead-lined copper heating coils 11,039 kgs. of 9 deg. B. liquor at 31 deg. C. were concentrated to 3091 kgs. of 31 deg. B. at 148 deg. F. = 64.45 deg. C. average boiling temperature in 10.4 hours.

$$W = W_w - W_c = 11,039 - 3091 = 7948 \text{ kgs.}$$

By taking into consideration, that

$$t_2 = 108.89 \text{ deg. C. (Fig. 61).}$$

$$t_1 = 64.45 \text{ deg. C.}$$

$$t_0 = 31.0 \text{ deg. C.}$$

we find the heat transmission coefficient to be  $C = 876$  calories per square meter and hour and the evaporation per square meter and hour to be 65.38 kgs. water.

Comparison with the first run will show that the same apparatus under nearly the same conditions has evaporated 10 kgs. water less per square meter and hour (65.38 instead of 75.3 kgs). Accordingly the heat transmission coefficient was lower (876

instead of 1107 calories per square meter and hour). This run No. II was made about six weeks after the run first mentioned above. There is no doubt that the heating surface was very much more coated with scale. Naturally such conditions should always be avoided and the endeavor should be to keep the heating surfaces as clean as possible.

This second evaporation process lasted from 10.40 a. m. till 10.15 p. m. and all the records can be seen on charts Fig. 61 (temperature of the boiling liquor), Fig. 62 (heating steam pressure which determines the temperature of the heating steam), Fig. 63 (exhaust steam pressure which determines the temperature of the exhaust of the heating steam), Fig. 64 (the temperature of the condense water), and Fig. 65 (the vacuum under which the process was carried out).

#### Third Run.

I will now discuss the concentration of three different liquors, all of which have originally different densities and are to be concentrated to the same density.

The same single effect was used as before, equipped with all controlling gauges. But in contradistinction to the former runs, in the third run only this vacuum pan was connected to the vacuum pump and condenser. The time of evaporation was from 8.15 a. m. till 12.20 p. m. or 4 hours 5 minutes. The conditions of the liquors were as follows:

No.	—Thin Liquor.—			—Concentrated Liquor.—		
	B.°	C.°	Quantity	B.°	C.°	Quantity
1	9½	20	1936.64	41	55.55	381.52
2	21½	56	1829.33	41	55.55	821.37
3	26½	56	2809.8	41	55.55	1573.5

According to our formula:

$W = W_w - W_c$ , the following quantities of water were evaporated:

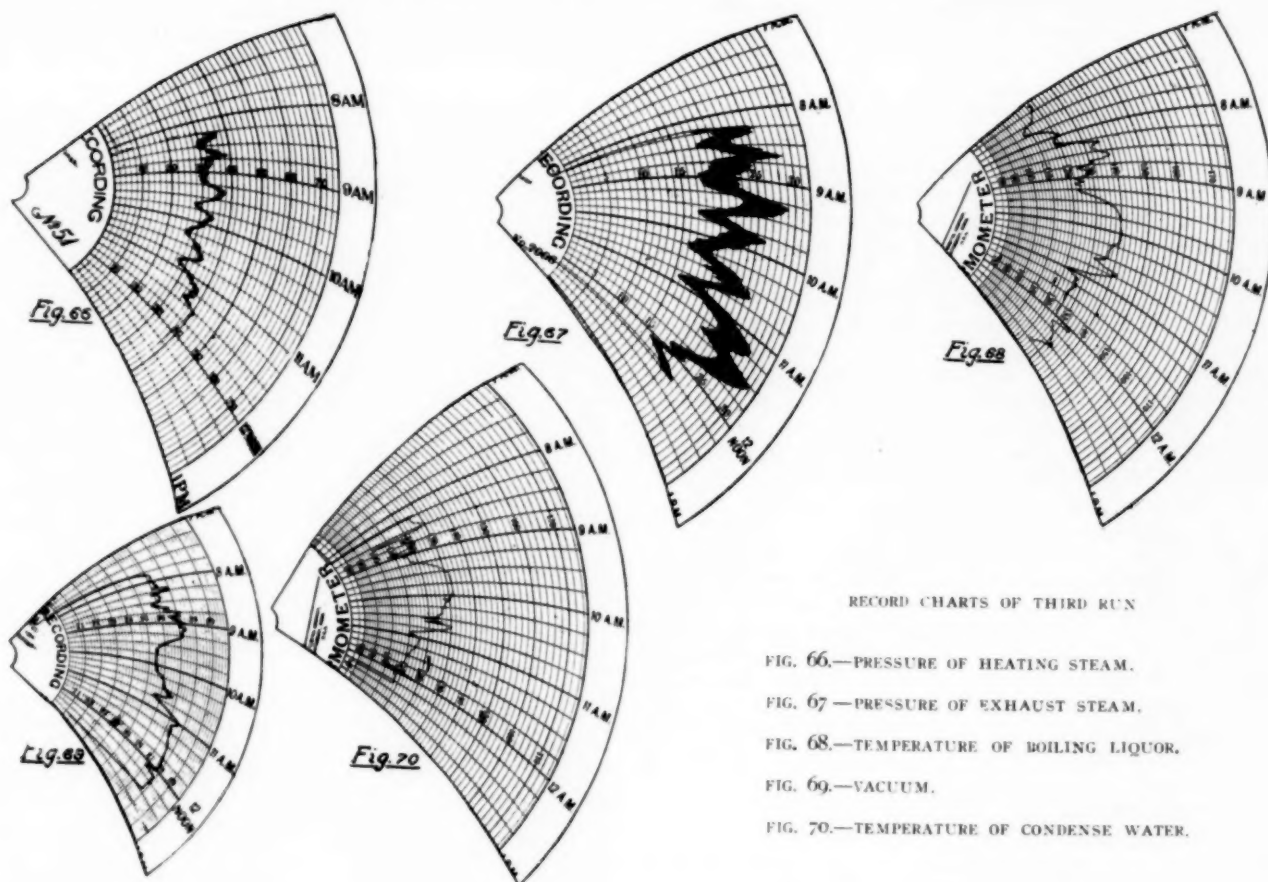
$$(1) 1936.64 - 381.52 = 1555.12 \text{ kgs.}$$

$$(2) 1829.33 - 821.37 = 1007.96 \text{ kgs.}$$

$$(3) 2809.80 - 1573.50 = 1236.30 \text{ kgs.}$$

As can be seen on each recording chart, the time of evaporation was 4 hours and 5 minutes. The evaporated water per square meter and hour was 86.69 kgs.

From our formula the heat transmission coefficient  $C$  can be found, taking into consideration the average pressure of the heating steam (Fig. 62).



RECORD CHARTS OF THIRD RUN

FIG. 66.—PRESSURE OF HEATING STEAM.

FIG. 67.—PRESSURE OF EXHAUST STEAM.

FIG. 68.—TEMPERATURE OF BOILING LIQUOR.

FIG. 69.—VACUUM.

FIG. 70.—TEMPERATURE OF CONDENSE WATER.

$t_2 = 33 \text{ lb.} = 256 \text{ deg. F.} = 124.44 \text{ deg. C.}$   
and the average result is

$C. = 7.38 \text{ calories per square meter and hour.}$

By comparison with the two former runs, it will be seen that although in the third run the coefficient of heat transmission was lower, yet the evaporated quantity per square meter and hour was much larger than in the two previous cases.

The reason is simply that the evaporating process was not disturbed by any changes made with other vacuum pans. Such changes cannot be avoided of course, with a crowded vacuum plant, where many pans are served by one condenser and one vacuum pump. This result shows plainly the disadvantages of such a plant and is a convincing proof in favor of the one-vacuum-pan, one-condenser, one-vacuum-pump system.

Fig. 67 shows an ideal exhaust recording chart, where the variations correspond perfectly to the variations of the heating-steam pressure.

The variations of the boiling temperature can be seen in Fig. 68. The variations are due mainly to the temperatures of the different liquors which are drawn into the vacuum pan. Toward the end of the concentration the temperature is kept well uniform.

Fig. 69, the recording chart of the vacuum, under which the evaporation takes place, shows very clearly the close connection between the boiling temperature and vacuum. The higher the vacuum can be kept, the lower will be the boiling point, and vice-versa. This point has to be taken into consideration in connection with the quantity of cooling water.

Comparing further the boiling temperature with the temperature of the condense water (Fig. 70) we see the advantages of the method of maintaining the temperature difference between the boiling point in the last body of a vacuum plant and the condense water always at 10 deg. to 15 deg. even if the temperature is not kept uniformly. With this subject, however, I will deal in greater detail in my next articles about condensation.

### The Experimental Ore Dressing and Metallurgical Plant of the Colorado School of Mines.

BY VICTOR C. ALDERSON

President, Colorado School of Mines.

The opening of the experimental ore dressing and metallurgical plant at the Colorado School of Mines is an epoch-making event in the history of mining in Colorado comparable with the discovery of gold on Cherry Creek in 1859, the erection of Senator Hill's smelter at Black Hawk in 1867, the successive regeneration of Leadville, the discovery of Cripple Creek, or the application of cyanide to low-grade gold and silver ores.

Commercial ore testing plants are not unknown. They have been established as adjuncts to mining machinery houses; they have been promoted by private capital; they have generally been satisfactory and have benefited the mining industry. The plant at the School of Mines will in no way compete with these private establishments. Rather will it increase their business by calling the attention of mining men to the necessity of a careful preliminary investigation of their ore before they erect a costly mill.

#### The Need of an Experimental Plant.

The problems that confront the mining man in the treatment of his ore are greater than those confronting him in raising his ore to the surface, i. e., the metallurgical are more serious than the mining problems. The passing of the high-grade ores, except in lucky finds, has brought the industry to the point where low-grade ores must be treated at a profit or the mining industry must go into eclipse.

Each camp, each mine, and even each vein has its characteristic problem. In Boulder county, Colorado, the problem is not only to concentrate the tungsten ores, but at the same time to save the gold content. The low-grade ores of Clear Creek



and Gilpin counties need cheap local treatment. Leadville faces the problem of handling zinc-carbonate ores which carry less than 20 per cent of zinc. The problem of Cripple Creek is to treat low-grade telluride ores by an adaptation of the cyanide process without preliminary roasting. It is estimated that \$100,000,000 is lost every year by inefficient methods of ore treatment. This loss should be stopped.

The greatest need of the mining industry in Colorado is a more thorough knowledge of ore treatment, more technical skill, greater refinement in mill operation, besides more careful economy and business efficiency. The time is past when the average mine can withstand waste, extravagance and loose management. The mine operator must learn that every dollar per ton saved in operation is equivalent to an increase of a dollar per ton in the value of his ore. He must learn just the character of mill which must be erected to treat his ore. This experimental plant will, undoubtedly, cause great economy in two lines: in the erection of mills and in the time saved in preliminary experimental work.

#### The Building.

The building of the experimental plant is situated on the bank of Clear Creek, a few blocks from the campus of the School. The slope of the bank is in itself sufficient to carry off water with considerable solid matter in suspension. The building is 98 by 141 ft. 8 in. on the ground floor. The frame work is of structural steel resting on concrete foundations which have been carried down to a substantial bed of gravel. The walls consist of 2½ in. of cement mortar, reinforced by "hy-rib," and are of natural cement color. The roof is of elaterite resting on a 2-in. sheathing of matched Oregon fir. The ground floor is concreted throughout and is divided into three sections of different elevations. Above the ground floor, but covering only a part of the area, are two suspended floors of reinforced concrete, supported by steel frame work. The building is well lighted and is ventilated by an easily operated monitor ventilator.

#### Power.

All machinery and apparatus requiring power is operated by alternating-current motors supplied with current from the School of Mines power house. For the generation of the current required, a producer-gas-power-generator unit of 80-kw capacity has been installed in the power house. This unit is of Westinghouse design throughout and consists of a bituminous suction gas producer, a vertical three-cylinder gas engine, and a direct-connected alternating-current generator.

The producer has a number of noteworthy features. The principal one, and the one which contributes so largely to its success, consists of the two distinct fire zones. This feature makes it possible to operate successfully on very low-grade fuel, and eliminates the difficulties usually arising from the tar and hydrocarbons given off and deposited during the process of gas making. Ordinary Colorado lignite coal is used. From this is produced a cool, clean gas with a heat value of from 115 to 130 B.t.u. per cubic foot. To eliminate the loss of power on account of a reduced intake pressure, a motor-driven, positive-pressure type of exhaustor is used. This draws the gas from the producer and delivers it to the engine at a pressure corresponding to about 4 in. of water.

The engine is of the standard Westinghouse vertical three-cylinder type, single acting, and using a four-stroke cycle. The cylinders are 15 by 14 in. (stroke). At a speed of 257 revolutions per minute, the engine, operating on the producer gas, delivers 118 brake-hp. Compressed air is used for starting, and both engine and producer can be started readily, even though having stood idle for several days.

Direct-connected to the engine through a flanged coupling is an 80-kw, 2300-volt, three-phase, sixty-cycle generator. The current is transmitted at this voltage to the experimental plant where it is stepped down to the working voltage of 440. The installation is such that the 80-kw machine can be operated in

parallel with a steam turbine in the power house. In case of an emergency all power can be supplied from the turbine alone.

#### Water Supply.

A concrete-lined well, 5 ft. in diameter and 25 ft. deep, has been sunk near the bank of Clear Creek. A 4 by 6-ft. tunnel, 120 ft. long, extends from the bottom of the well to a stratum of gravel under the bed of the creek. The well and tunnel have a storage capacity of 20,000 gal. The pumping outfit consists of an automatic motor-driven, submerged-type, two-stage centrifugal pump. This has a capacity of 100 gal. per minute against 50-lb. pressure, pumping into pressure storage tanks of 2500-gal. capacity. An ample supply of clear water is thus assured for all operations.

#### Sections.

The plant, when fully equipped, will consist of four sections or units—sampling, concentration, cyanidation, and a fourth devoted to roasting and special apparatus, such as magnetic and electrostatic separators, dry tables and flotation schemes. For general equipment the plant will contain a Curtis air compressor, a two-stage centrifugal pump, three large water supply tanks operating under air pressure, two motor-operated platform elevators, giving control over all the floors, a Ruggles-Coles dryer, ore bins, track scales, turn tables and ore cars.

The sampling section will contain the following equipment: one Vezin sampler, one Brunton sampler, a portable feed hopper, one set 12 by 20-in. Traylor rolls, one 2 by 6-in. Sturtevant roll jaw crusher, with accessories for finishing the sample such as laboratory crusher, and pulverizers, bucking board and rifles. In addition to this a complete gasoline assay furnace outfit will be installed.

The concentrating unit will consist of one 7 by 10-in. Blake crusher, one Samson crusher, one 2D Gates gyratory crusher, one set 14 by 30-in. P. & M. M. rolls, one set 12 by 24-in. P. M. M. rolls, one set triplex rolls, one 3½-ft. Huntington mill and one 3½-ft. Akron Chilean mill for regrinding, one Richards pulsator jig, one Harz jig of one compartment, one Harz jig of five compartments, one standard Card table, one No. 6 Wilfley table, one Wilfley slimer of latest design, one Johnston vanner, one Traylor vanner, one Richard pulsator classifier, one three-compartment classifier, two Callow cones, grizzlies, impact and revolving screens, sampling devices and the necessary sand pumps, elevators and concentrate driers. In addition the concentrator will contain a battery of five 850-lb. gravity stamps, equipped with amalgamating plates, Pierce amalgamator and clean-up pans. A special feature of this unit will be the installation of small-sized apparatus for the handling of small ore lots, *i. e.*, a Callow miniature ore-testing plant, a quarter-size Wilfley table and a quarter-size Card table. Through this arrangement, ore lots of any size whatever may be tested efficiently.

The cyanide section will contain one 3-ft. tube mill, one 3½ by 10-ft. Pachuca tank, one Paterson agitator, a Dorr classifier, a Dorr thickener, thickening cones, a Butters filter, one six-compartment zinc box, one lead-lined acid tank, one filter press for zinc slime, solution storage tanks and a small pebble mill. This department also will be provided with small-scale apparatus in the shape of agitators and precipitating devices.

In the fourth section provision will be made for the installation of special machinery, whereby its efficiency may be tested and comparison made with standard apparatus; for testing by roasting and magnetic or electrostatic separation, by dry tabling, and by such new processes and apparatus as may from time to time come before the metallurgical and mining public.

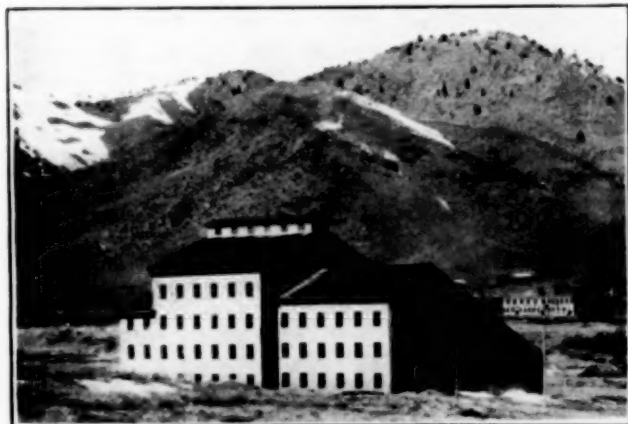
#### The Importance of Preliminary Treatment.

The proper preliminary mechanical preparation of an ore is one of the most important metallurgical problems with which we have to deal. So many factors enter into its consideration

that it becomes a very complex question. The nature of the ore, the state of aggregation of the constituents, the commercial conditions for disposal of products, and other factors have their influence.

If the ore, like the copper sulphide of Butte, is in a state of coarse aggregation, then coarse crushing with concentration beginning at the maximum size—in this case about 2 in. in diameter—is used for the double purpose of keeping the production of slime at a minimum and also producing as large a quantity of coarse concentrate for the blast furnace as practicable. In general, it is a safe rule to reduce ore only to the requisite fineness to secure satisfactory results and to avoid slime—the bane of the concentration man.

In cyanidation it may be necessary to reduce only to  $\frac{3}{4}$ -in. diameter in order to secure a practically complete extraction as was done in the early Mercur practice; on the other hand, it may be necessary to bring all the material to a practically impalpable powder as in the case of the all-slime treatment of silver ores. Each case presents a problem of its own, the successful solution of which means much in the subsequent treatment of the ore. In order to carry on this preliminary treatment at a minimum expense small-size equipment is installed. For a preliminary investigation on small apparatus, a mine owner may send 50 lb. On this small amount, work may be done in any one of a variety of ways, the results of which



EXPERIMENTAL ORE DRESSING AND METALLURGICAL PLANT OF COLORADO SCHOOL OF MINES.

will point to more extended work, possibly on a car-load lot. By this means a mine owner may, at a minimum cost, and with the maximum amount of investigation, learn what process is best adapted to his ore and what kind of a mill to erect. This will appeal especially to the small mine owner, for it puts him on an equality with the large corporation. The wealthy mine owner can employ the best talent because he has the money to pay for it. But the School of Mines' plant will be available to everyone.

#### Flexibility.

A special feature, carefully considered in building the plant, is its flexibility. The installation of launders, conveyors and elevators is so arranged that any combination or variety of tests may be made. Ore may be taken from one part of the plant to any other for comparing the effect and value of different screens, classifiers or concentrators working upon the same material and under similar conditions. This is an important feature because it will enable a wide range of work to be done. If there is any solution whatever to the problem of the reduction of rebellious ores it certainly can be discovered by means of the facilities of this plant.

#### Self-Salting.

The utmost pains have been taken to avoid self-salting. This precaution is especially necessary when successive tests

follow each other closely. To avoid this danger all launders are designed to be easily flushed; compressed air is installed for cleaning, and all obstructions to the free passage of ore are removed.

#### Educational Features.

Although the location of the Colorado School of Mines is an ideal one, and it is possible to see practical ore dressing and metallurgical plants at any time, this fact does not make the need of an experimental plant at the School any less imperative. The School takes advantage of its location by requiring numerous carefully conducted inspection trips, in which students, in squads of small numbers, are required to make detailed studies of processes in operation and to hand in reports of such studies. By a series of outlines, each devoted to some particular practice, care is taken that no detail of importance is overlooked. This method produces excellent results, is carried out as fully as possible, is of immense value, and is a very important part of the curriculum. Visits of inspection, however, are necessarily limited in time, and admit only a cursory study of operations. Furthermore, it is difficult, if not impossible, to study the mechanism of a machine while it is in motion. What is needed is a plant with type machines which can be studied under all conditions, and which can be adjusted so as to answer the requirements of experimental work.

The fact remains that the best results these inspection trips can accomplish is to bring about the knowledge of the particular practice, good or bad, at the plant visited, without the opportunity of learning how or why the practice produces the results obtained. In the study of concentration, for example, breakers are run at a certain speed, with jaws at some fixed distance and with the feed regular or irregular. What should be done is to show how a variation in one or more of these conditions affects the results. This cannot be done without an experimental plant, for no manager would be willing to have the regular course of operations disturbed in order to afford an object lesson to a group of students. In like manner the size of feed to rolls, the diameter, the distance between rolls, the spring pressure, and the manner of feeding are all important factors in securing quality and quantity of product. With commercial requirements to be considered, as is necessary in the usual plant, it is impossible for a student to learn experimentally the relative influence of these various factors.

It is very desirable to determine the relative capacity and efficiency of various screens; for instance, trommels and impact screens and especially new types recently introduced, for rarely does an individual plant employ both. For some reason one form or the other is adopted, and the possibility for the only proper comparison of value—that wherein both machines are working on the same material—is never afforded. As soon as a plant is in successful operation, the routine involving the rate of feed, the proportion of water, speed and stroke of machines is established and unless some radical change is decided upon in the practice these conditions are unvaried.

In the apparently simple process of gold milling the practice is so varied that unless it is possible, by means of an adjustable battery, to compare the different methods, students can form no true idea of the influence of these variations. It would be possible, in an experimental plant, to investigate every important detail of construction, to see how variations of all kinds affect the economy of operation, to appreciate the effects of various losses, and to determine their influence in operations on a commercial scale.

Perhaps the educational advantages which result from the possession of an experimental plant are nowhere more evident than in the improvement made possible in the thesis work of the seniors. Thesis subjects are now very limited in range; most of them may be grouped under one of two heads—the treatment of a specific ore, or a report on a mine. The former cannot be treated properly under existing conditions. The study of the amount and character of the work done by the various ore dressing machines is not possible at present, be-



cause no plant will permit the attachment of measuring devices which absorb useful power of direct cash value. So, too, a comparison of plate amalgamation with amalgamation by the Pierce device becomes impossible because we cannot compare the work of the methods on the same ore under similar conditions. An experimental plant like the one at the Colorado School of Mines, therefore, serves the purpose of a laboratory in a most practical and useful way.

#### Research Features.

Besides supplying the students of the School with a superb laboratory and thereby increasing the efficiency of their studies, the plant can be used as a research laboratory by the faculty and the alumni of the School. Problems of ore treatment applicable to ores of wide occurrence—problems which affect not only a single mine but a whole district—will be investigated and the results published.

The facilities of the plant also will be available to experts who desire to make investigations of their own. In addition to all this, floor space has been reserved for testing new devices. An inventor who wishes to perfect his invention can have all the facilities of power, water, floor space, ore supply and expert assistance at his command at a slight expense and will not be obliged to incur the heavy cost of equipping a plant for his one invention. The plant, then, will serve not only the needs of the School in an educational way, but will be a means of acquiring much information of great value to the mining industry.

#### Commercial Testing.

Commercial testing will be done in one of two ways:

(a) When ore is sent in to be tested the work will be done by the manager, assisted by the corps of assistants connected with the plant. The manager will make a report to the consignor and be responsible for the accuracy of the results. In no case, however, will such report state that the ore comes from any particular mine or locality, unless a member of the corps goes to the mine and takes the samples.

(b) Ore may be sent to the plant for testing and the owner may designate some expert who will have charge of the test and make a report only to the owner. In this case the expert in charge will be allowed the assistance of the manager and the regular corps at the plant. All the facilities of the plant will be at his disposal and he will be responsible for the accuracy of the results.

The second method, it is thought, will be most satisfactory to the mine owner and is, therefore, recommended. Facilities for the transportation of ore are afforded by the Colorado and Southern Railway and the Denver & Intermountain Railroad Co. Circulars of information, giving the cost of tests and other details, will be issued later.

#### Appropriations.

Two appropriations have been made for the erection, equipment and operation of the plant: \$75,000 by the Seventeenth General Assembly and \$50,000 by the Eighteenth General Assembly. The first has been expended in full and the second as yet only in part.

#### The Personnel.

Inasmuch as this plant differs in size, plan and scope from other commercial or educational plants now in existence, the drawing of the plans was a long and tedious operation. First, the faculty proposed, in a general way, their ideas to the consulting engineer, Frank E. Shepard, president of the Denver Engineering Works Company. He, assisted by Philo D. Grommon, a graduate of the School of the class of 1907, worked on the details in collaboration with Professors Traphagen and Haldane of the School.

Then, when nearly completed, the plans were submitted to two prominent engineers of Denver, D. W. Brunton and Philip Argall. Reduced copies of the plans were then sent to a large

number of engineers in different parts of the country for suggestions and criticisms. Finally a prize of \$50 was offered to the graduate of the Colorado School of Mines who should offer the best suggestion for their improvement. This prize was awarded to Wallace A. Stephens of the class of 1893.

The plant is organized as a department of the School with F. W. Traphagen as director, and William G. Haldane as manager in immediate and active charge of tests. Practical mill men and skilled mechanics will be employed as the need for them becomes apparent. In no case will inexperienced students be allowed to carry on commercial tests. Such work will be done only by the regular experienced corps connected with the plant.

An advisory committee, consisting of the following men also has been appointed: D. W. Brunton, Denver, Colo., mining engineer; Philip Argall, Denver, Colo., manager Stratton's Independence; John Tait Milliken, Colorado Springs, Colo., consulting engineer; Thomas B. Crowe, Victor, Colo., superintendent New Portland Mill; William G. Swart, Denver, Colo., Western representative American Zinc Ore Separating Co.

#### Conclusion.

The possession of this plant enables the school to enter that broad field of usefulness that lies outside the distinct educational work of educating mining engineers. In every industry there are many problems, too large for the individual operator, which naturally can be solved best by the state or federal government. The government surveys the coast lines, maps the shoals, erects the lighthouses, prepares tables which show high and low water at all points on the coast; but, after supplying all this information, the government leaves the captain to manage his own ship.

The German government keeps a fostering eye upon all its industries. If any particular industry needs free raw material, the needed legislation is passed; if it needs a protective tariff until it can stand alone, such protection is enacted into a law; if a technical school is needed in which to train skilled workers, the government sees that such a school is established; if low freight or steamer rates are needed, the reductions are made; if better banking facilities are required, they are provided. And yet when all this is done by the government the individual operator must manage his own business.

Parallel with these illustrations is the work of the experimental ore dressing and metallurgical plant of the Colorado School of Mines. By means of this plant, knowledge of great theoretical and practical value to the ore dressing and metallurgical industries will be obtained, exhaustive tests will be made to indicate the character of the mill that should be erected to treat any particular ore successfully, but the operator must still build and manage his own treatment plant.

#### Victims of the Titanic Disaster.

Through the Titanic disaster metallurgy has suffered a heavy loss in the death of the following members of the profession:

**Benjamin Guggenheim**, one of the seven sons of Meyer Guggenheim.

**H. Forbes Julian**, chief metallurgist of the Butters Patent Vacuum Filter Co., a pioneer in the South African gold-fields in the eighties, one of the authors of "Cyaniding Gold and Silver Ores."

**Edgar J. Meyer**, vice-president of the Braden Copper Company.

**Ernest A. Sjostedt**, well known to our readers through his electrochemical pioneer work carried out for the Lake Superior Corporation at Sault Ste. Marie (including the manufacture of ferro nickel in the electric furnace).

**George D. Wick**, of Youngstown, Ohio, formerly connected with various steel companies in the Middle West.



### The Abuses of Our Patent System.\*

BY DR. L. H. BAEKELAND,

President of the American Institute of Chemical Engineers.

A recent decision<sup>†</sup> of the Supreme Court upholding the right of patentees to dictate under what conditions a patented article shall be sold, or shall be licensed, has become the object of much criticism. One of our newspapers repeats the comment that this decision, interpreted to its extreme limits, so as to mean that "it would enable the patentee of a window frame to dictate that all the material of a house in which the frame was to be used, must be procured by him." But that argument overlooks the fact that nobody is compelled to buy that particular patented window and that the public at large can purchase any other window frame not patented, or of which the possession is not submitted to any restrictions.

The decision of the Supreme Court simply means that the owner of a patent, in selling or licensing under it, has the same privileges as the owner of any other private property. For instance, the proprietor of a lot can sell it with the restriction that if any house is to be built on it, the materials for this building shall be purchased from him. It all depends on whether the purchaser is willing to submit to these terms or prefers to forego acquisition under such restrictions. To assail this decision of the Supreme Court, is to deny the elementary rights of private property, or to deny that a patent is private property.

Justice Lurton, in expressing the majority opinion of the Supreme Court, very correctly says: "When the patent expires, the public will be free to use the invention without compensation or restriction."

Outside of this limitation, why should restrictions be put upon ownership of patents, which do not exist for other forms of private property? An invention is the creation of something which did not exist before. Is the creator of this invention not entitled to undisturbed ownership, at least for a short period of 17 years, when the ownership of real estate, or other private property is undisturbed and continues for ever?

And yet, real estate always existed long before it got in the hands of private owners. Its mere possession does not imply any special merit, nor does the private ownership of real estate confer any benefit upon the community. Nevertheless, real estate can be left idle at the whim of the owner, who in the meantime, benefits by the enhanced value, the unearned increment, conferred upon his property through the enterprise of the community at large, and more specially by the enterprise of his immediate neighbors, who take the trouble and the risk to develop their own real estate, while he just remains inactive.

So that, in this and many other ways, the owner of real estate, or other private property, has an incomparably greater scope of unquestioned property rights than a patentee. Furthermore, these rights do not cease after 17 years, but continue for ever.

It is a significant fact that in many cases the persons who object most to patent rights are just those who have lived in surroundings, where industrial or intellectual development is least apparent.

In some parts of the country, the word "patent" is scarcely known, and the conception of a higher class of property than that which is merely acquired by inheritance or money purchase, is difficult to understand. On the other hand, the conception of intellectual property rights, is one of the symptoms of a higher state of civilization.

I may point out on this occasion, that the little state of Connecticut, takes out more patents than all the Southern States together.

Most people imagine that patent laws are for the exclusive benefit of inventors, and this regrettable mistake leads to many misunderstandings. Were this opinion correct, patent laws would mean class legislation, and would be as unfair, as undemocratic, as unwholesome, and as dangerous as any other class legislation.

But the patent laws as framed under the Constitution of the United States, are primarily conceived for the benefit of the nation. No country has benefited more by its patent system than the United States. Compare the tremendous industrial development of such nations which have liberal patent laws, like the United States, Germany, and England, with that of the Latin countries, where patent laws are less favorable to the inventor.

There is one civilized country, Holland, which up till recently had no patent law whatever and allowed the unrestricted use of any invention. This ought to have been the Paradise of Infringers; it was easy enough to use freely in Holland processes patented in other countries, and to distribute from there infringing goods to all the countries of the world. Yet what was the result? Holland, with her highly developed commerce, her abundant money supply, with a race of intelligent and enterprising men, remained industrially undeveloped, and still ranks as one of the least among the industrial countries of the world. Why? Because there was no incentive to saddle oneself with all the risks and outlays of starting a new enterprise or of improving methods of manufacture, knowing beforehand, that in case of success, one's neighbor could simply do the same thing without any restriction whatsoever.

This standpoint that good patent legislation is for the benefit of the whole nation, is too often lost sight of and it behooves every good citizen of this country to help improve our patent laws and the administration thereof. A patent is simply a contract between the nation and an individual, the inventor. By that contract, the inventor discloses to the community at large, the results of his intellectual work; by doing so, he enables others to get acquainted with his work, and to improve thereon, and this stimulates further research, invention, and enterprise. You will find that newly disclosed patents are usually followed in rapid succession by several improvements thereon, conceived by others, but patterned on the original invention. The inventor, in disclosing his secrets, confers a benefit on the nation, and the nation, in return, gives him for a rather short number of years, the sole use of his invention—followed immediately afterwards by absolute confiscation in favor of the public. The period of this limited monopoly is none too long if we take into consideration the time it takes to develop an invention into commercial shape; in many cases, inventions reach the money-earning stage only after the patents on which they are based have expired. In the meantime the disclosures made by the inventor stimulate enterprise and further invention, and induce the ideal form of competition—competition by improvement.

So that, practically, the granting of a patent is simply a business contract between two interested parties; the nation and the inventor.

Up to this point everything goes well enough. Our patent laws, although not perfect, are generally considered as a model of good patent legislation; they were conceived in a broad and fair spirit, and the best answer to those who find too much fault with them is, that in all foreign countries, including Germany, whenever a modification has been made in their patent laws, the change has always brought them a step nearer to the American patent system.

The real trouble begins when this business contract between the nation and the inventor has to be enforced. It is there that the patentee does not get "a square deal." After the inventor has faithfully performed his part of the contract, and has disclosed his invention to the nation, the nation hands him a "gold brick."

Woe, indeed, to the poor inventor who tries to enforce his rights against wealthy infringers, aided by skilful lawyers:

\*A paper read on April 19th in a joint meeting of the New York Sections of the Society of Chemical Industry, the American Chemical Society and the American Electrochemical Society.

†*Sidney Henry et al., vs. A. B. Dick Co.*, March 11, 1912, No. 20, October Term, 1911.

His well engraved United States patent parchment may then become his certificate of entrance to the poor house, or to the lunatic asylum. All this tends to discourage invention by independent individuals and paralyzes the stimulation of invention our Constitution intended to promote by the patent law.

In other words, although the patent law of the United States is about as fine a piece of good progressive legislation as was ever conceived, its enforcement in the United States Courts, is subject to so many uncertainties, complications, delays, and to such horrible expenses, that the man with limited resources is at an inexpressible disadvantage.

If any one asks my advice, whether he should take out a patent or not, my invariable answer is: "Can you find the money to defend your rights in court? If not, do not waste any time or money on a patent."

Here, then, is an instance of a beneficent and well planned law, meant to be fair to everybody, which through absurd rules of practice and procedure, as sanctioned by American courts, has entirely deviated from its purposes. Meant to stimulate research and industrial development, it has merely become a pretext of playing bluff against bluff, tricks against tricks, by skilful acrobats of the profession of law.

As our patent law is used now, it is certainly a Godsend for large corporations, lawyers, and experts.

About three years ago, one of our most successful law practitioners, a candid man, declared publicly before the N. Y. Section of the American Chemical Society,\* that as he was about to retire from business, he had no further hesitation in stating that in the many patent cases he had won for his clients, the latter seldom, if ever, got any settlements for damages, and if they did, it was a mere fraction of the fees he had collected from them for defending their case; he took the occasion to uphold to ridicule the absurd conditions prevailing in our courts, which make this possible.

Some experts reap just as golden a harvest by this state of affairs. Not so long ago, I overheard a chemist, whose specialty is to testify in patent cases, discussing with an opposing expert a patent case in which he was retained; his conversation was boisterous enough that any one present could hear it: "This is the most interesting patent we ever had in that line," he said. "Do you realize the fact that this means for you and me at least \$5,000 a year for at least five years, and . . ." he significantly added, "this will give us an opportunity to learn much organic chemistry."

This, indeed, is the way some experts get their knowledge of chemistry: their clients pay for their tuition.

As to wealthy corporations, it has become obvious that the skilful handling of patent cases places them at an untold advantage against their smaller competitors. For them, a well-organized patent department is a reliable machine, where money is the lubricant. This machine, in its slow but sure grinding way, can reduce to pulp any of the smaller competitors. For large corporations, the maintenance of such a machine with a staff of lawyers and experts, is merely a small side expense. By its aid, they can bluff their weaker competitors into quick submission. If this is not successful, they can drag out a patent suit indefinitely, until the weak opponent, unable to bear the ever-increasing expenses, collapses and withdraws.

These tactics are well known and have been played successfully, whether it was to uphold a worthless patent, or to obtain immunity in case of infringement. In every case, the wealthy corporation is sure of the outcome of the game and plays "Heads I win, tails you lose."

Although these facts are sufficiently known by all who have practical acquaintance with patent litigation, the public at large is ignorant thereof, and cheerfully imagines that the inventor has a sure thing and that everything comes his way. We hear fairy tales of the fabulous wealth of inventors. I know many inventors, and I can tell you that very, very few of them ever

obtained any important sum of money by their inventions, as such. If some have become rich, it is as manufacturers or as business men, and not merely by selling inventions. Most patents sold as such do not even repay the expenses involved in the preliminary work connected with them.

As matters stand now, the public does not get the benefit of our patent laws, and the law thus misses its highest purpose. Our degenerated rules of practice and procedure simply serve to strengthen the rich and mighty, who apparently disburse the funds for litigation, but in the end make the consumer, the public, pay the bill. But the consumer does not know this, and in his cheerful ignorance believes, in the meantime, that he has nothing to do with patent laws and patent litigation, so the matter does not interest him. On the other hand, many public spirited lawyers, disregarding narrow-minded professional interests, have spared no pains to expose this condition of affairs and have urged reforms.

Why, then, should this state of affairs have persisted so long? Why should our otherwise excellent patent laws have become so perverted in their applications? Simply through the sheer indifference of the directly interested parties: the public and the inventor.

As to the inventor, he is most to blame. I have met few inventors, who when asked for a remedy, did not come out right away with impractical or far-fetched cures. Most of them want to make a radical change in every department of our patent system, forgetting that it is easier to break down than to build up. Others suggest pet remedies of their own, but the worst of all is that no two inventors can agree on the subject. In justice to the inventors, I should mention that most of the lawyers I have met, are in the same predicament. In the meantime, the real fact is that very few reforms are necessary in order to remove the absurd conditions of our patent system, and these reforms can easily be accomplished if we only can agree on them. This I shall try to explain:

Formerly, all patent cases, on appeal, went by right, from the lower courts to the Supreme Court of the United States. The latter court not only rendered final decisions, but, what is more important, saw to it that the proper rules of practice and procedure were observed in the lower courts. The Supreme Court acted practically as a supervising body on our patent system, and lent considerable prestige to it. But through the rapidly increasing development of this country, the cases before the Supreme Court became so numerous that finally it took three to four years, after an appeal was filed, before a case could be heard. This amounted practically to a denial of justice, because some of the patents expired before their case was reached.

So in 1891, a remedy was inflicted, which has proved to be much worse than the ailment. Nine Circuit Courts of Appeal were organized, and each court, independently, can give final decision in patent cases. This has brought us into an intolerable condition of affairs. Indeed, each Circuit Court of Appeals can adjudicate only for its own circuit, and being independent of control of any other Circuit Court of Appeals, each court makes decisions as it thinks right, based upon the evidence submitted to this special court, and in accordance with its own view of the law. *So that we have now this absurd condition that some patents are valid in some parts of the country and invalid in others.* Any litigant with much money, who has been beaten in one circuit, can carry on his infringements with impunity in an adjacent circuit or drag on new suits forever and a day. While doing so, he knows very well that he can postpone a final decision as long as he is willing to pay his lawyers. But this is not the worst of the situation. Since the Supreme Court of the United States is no longer by right the final arbitrator in case of appeal, our whole patent system has lost the prestige and corrective influence of a final court supervising the faithful observance of proper rules of practice and procedure.

I am told that we have some good rules of practice formu-

\*This journal, 1909, vol. VII, p. 77.



lated long ago by the Supreme Court, but that since the practical elimination of this court in patent cases, lawyers and experts have acquired the habit of disregarding these rules or "waiving them by courtesy" for reasons of their own. I am even told that if these rules were honestly adhered to, the testimony of any patent suit could be ready for the court at the end of six months.

A bill for a Court of Patent Appeals has been pending now before Congress from year to year, and seems to meet with almost unanimous approval, even from lawyers. The only serious opposition seems to be on the part of some politicians, who do not like the idea of new judgeships being created, while their political opponents are in power. If this argument is kept up, the bill will never pass, unless we unite our voices to demand it.

Give us a Court of Patent Appeals which will render final decisions by which we can abide, instead of the absurd condition of affairs, where one Circuit Court of Appeals can oppose its decision to that of another. Give us a Court of Patent Appeals which shall formulate and maintain common-sense rules of practice and procedure, and will stop the abominable custom of taking unrestricted testimony without a presiding judge. Let us exclude all testimony which has nothing to do with the case, but which is entered as a trick to indefinitely prolong litigation; as a pretext to pad the records; as a technical dodge to drag on the case, and to defer judgment; as a means of saddling the poorer opponent with ever-increasing expenses until he staggers under the load and is ready to give up the fight, if in the meantime the term for which the patent has been granted has not expired.\*

Let testimony be taken in open court as it is done in Germany, in England, and by other nations, where cases are tried and settled at relatively small expense and in a short time, instead of taking many, many years, as is often the case here. In Germany and in England, patent infringements are treated just like any other violation of property rights; with the same severity as though somebody had stolen or damaged another man's property.

While we are about it, let me mention the urgent need of a new Patent Office Building. That awkward Greek temple in F Street was acceptable enough when our country was so much smaller. It now has become a congested cumbersome unpractical fire-trap in which, some day, all the valuable rec-

ords of pending and allowed patent cases will be destroyed. Whenever this occurs, and it may happen to-morrow, it will prove a real calamity for those of our manufacturers whose business is dependent on patents. That fire will give unusually unfair opportunities of making money for those who live and thrive on patent litigation.

The patentees of the United States have paid, up-to-date, to Uncle Sam, about \$7,000,000 in excess of the expenses of the patent office. This fund has now accumulated to the credit of the patent office. Why should it not be used to construct a well equipped modern business building, where our patent records, which you and I have paid for, are kept in fireproof rooms? Such a building should be provided with all the equipment necessary for a thorough search. Many important references are not available in the patent office. It seems incredible, but complete copies of patents issued in some countries like Belgium, France and Canada, are lacking. If these lacking records had been available to the examiners, many invalid patents would not have been issued through sheer want of means of obtaining full information as to prior published disclosures. It is truly astonishing that under such handicaps, our over-worked patent examiners have been able to furnish so much good work. An up-to-date patent building should possess also a complete laboratory, where simple chemical and physical questions can be demonstrated promptly and easily.

A very desirable reform in the practice of the patent office, would be the introduction of the German system of public objection to an "allowed" patent, before it is definitely "issued." In Germany, in Austria and in England after a patent has been examined and allowed by the examiner, the title and the claims are published and the copies of the text can be obtained from the patent office. Then during a period of two or three months, objections to the issue of the patent can be filed in writing, by anybody. Copy of the filed objections are forwarded to the applicant, who then has a few months to file an answer. In this way, the examiner has the benefit of a thorough public discussion of the subject before that patent is definitely issued. This involves a delay of several months in the issue of a valid patent, but this is a very small hardship, indeed, if one takes in consideration the fact that a patent issued after severe public contestation gains much in value by its record. Furthermore, this way of proceeding is now successfully used in the U. S. Patent Office for the registration of trademarks.

Some other useful reforms have been suggested, reducing the needlessly large number of appeals in case of interference.

Our interference rules may appear very logical in accordance with the conception that in the United States, a patent belongs to the first diligent inventor, independently whether he be the first patent applicant or not, as long as his invention has not been in commercial use before that period. To the uninitiated, this may seem an excellent safeguard to insure that the first inventor should receive the reward of his intellectual work. Unfortunately, any poor inventor, who has been through interference cases, knows that without much money an interference case becomes almost a hopeless proposition if he has to deal with wealthy antagonists. Indeed, I know of an interference case which has been going on for the last six or seven years, and which has already cost one of the contestants over \$60,000. Even after the interference case is decided in one's favor, one has to take all the ordinary chances of further expensive infringement suits. Is this to the benefit of the public, for whom, primarily, our laws are created? Let us see: The public wants as early as possible a disclosure of any invention, and with that end in view, the patent law stimulates such disclosures by offering as reward 17 years of patent monopoly. Yet everybody knows that our interference system hopelessly delays the publication of an invention. Furthermore, our interference rules are in many ways a terrifying menace to the industries of the country.

For instance, a man applies for a patent. The patent is al-

\*Judge Hough in giving his opinion in the famous Seldon case, where 36 huge volumes of printed testimony were submitted, took occasion to denounce our absurd methods of patent litigation, as follows:

"It is a duty not to let pass this opportunity of protesting against the methods of taking and printing testimony in equity, current in this circuit (and probably others), excused if not justified by the rules of the Supreme Court, especially to be found in patent cases, and flagrantly exemplified in this litigation. As long as the bar prefers to adduce evidence by written deposition, rather than viva voce before an authoritative judicial officer, I fear antiquated rules will remain unchanged and expensive prolixity remain the best known characteristic of equity."

"But reforms sometimes begin with the contemplation of horrible examples, and it is, therefore, noted that the records in these cases, as printed, bound and submitted, comprise 36 large octavo volumes, of which more than one-half contain only repeated matter, i.e., identical depositions with changed captions and exhibits offered in more than one case. In reading the testimony of one side in one set of cases there were counted over 100 printed pages recording squabbles (not accompanied with apparent personal rancor) concerning adjournments—and after arriving at this number it seemed unnecessary to count further. In many parts of the record there are not five consecutive pages of testimony to be found without encountering objections stated at outrageous length, which may serve to annoy and disconcert the witness, but are not of enough vitality to merit discussion in 2,000 pages of briefs. Naturally tempers give way under such ill-arranged procedure, and this record contains language uncalled for and unjustifiable, from the retort discourteous to the lie direct. And all this litters up the court record room, while clients pay for it."

"Even when the evidence in equity was taken up by written answers to carefully drawn interrogatories, the practice was not marked by economy or celerity, but stenography and typewriting, the phonograph and linotype have become common since our rules were framed, have made compression and brevity old-fashioned, increased expense and often swamped bench and bar alike by the quantity rather than the quality of material offered for consideration."

"Motions to expurge and limit cross-examination should have been made in these cases, though they are feeble remedies exposing counsel to personal reproach and rendering judges afraid of keeping out of evidence what they cannot (on motion at all events) understand. But the radical difficulty of which this case is a striking (though not singular) example will remain as long as testimony is taken without any authoritative judicial officer present, and responsible for the maintenance of discipline and the reception or exclusion of testimony."



lowed and published. On the strength of this patent, a company is formed, which goes ahead, builds an expensive factory, and starts operations. Then frequently it has happened that an interfering patent application, which was not known to exist at the time the company was organized, embodies identical claims, and is put forward in objection to the published patent. This may invalidate the patent on which the company was formed, and thus stop and annihilate an enterprise which was begun entirely in good faith, and on a sound basis. Such a thing is impossible with the German system, where the first applicant, unless his application is based on fraud or theft, gets the patent, as long as no one else can prove prior use or prior public disclosure. Rigid examination, followed, after allowance, by a short period for public objection, makes the German proceedings relatively inexpensive, and gives added value and prestige to patents issued under this system.

It may be objected to this system that it induces filing an application before the invention is sufficiently ripe, but even with our system the same objection holds good. Furthermore, with our current methods, it is possible to file patents and let them pend for many, many years, and use these pending applications as a drag-net in which to catch any other patents which may be applied for by others, and by which to get the benefit of any practical developments or improvements which go on in the meantime; this was clearly demonstrated in the famous Selden case.

For deciding priority in purely scientific publications, it has been accepted, since the time of Humphrey Davy, that "priority of publication, unless in case of fraud, means priority of conception." This simple rule, if applied to the Patent Office system, would sweep away the most complicated and most expensive part of our Patent Office methods. At the same time, it would stop an interpretation of our patent law, which is decidedly dangerous and unfair to the unsuspecting public, and has no advantage to the inventor, unless he be rich, or unless he be propped by wealthy backers.

All these reforms, or improvements, whatever you want to call them, are relatively simple and might have been obtained long ago, if the real interested parties, the public and the inventors, had demanded them. If we unite in our demands, we can surely obtain them.

To the honor of the better class of lawyers, let me mention that the Patent Law Association of Washington, is doing good work to accomplish some much needed reforms. Lately, in conjunction with the American Institute of Chemical Engineers, and the Inventors' Guild, a start has been made in awakening the interest of our national engineering societies. Let us all join in this movement, and let us not overlook the fact that our legislators need as much education on this subject as the public at large. But if we try to suggest reforms, let us be practical and first concentrate our efforts on such reforms on which we all can agree. Let us avoid theorizing or dreaming. A perfect patent law will never exist, except perhaps in heaven, where all men are angels. After all men have become angels, patent laws, as well as other laws can be dispensed with. But we are still on earth and for a long time.

Remember that if there is much to criticize in our patent system, there exists the same chaos in our civil and criminal laws which badly need a general overhauling.

We chemists or engineers are apt to forget that though science, engineering, and all achievements based on exact knowledge and sound reason, have made immense progress in late years, our laws and the administration thereof, have advanced little beyond what they were two or three thousand years ago, so that they now are an anachronism badly adapted to our modern conditions of life. But most judges and lawyers, when they talk about dispensing justice, have acquired, like the Chinese Empire, the habit of looking backwards for "precedents," which for them will remain the most respectable and the most imposing arguments.

At this time, the immediate danger for our patent system, is

that some Congressmen or Senators, ignorant of the real situation, but anxious to advertise that they want "to fight the trusts," will rush through bills which will work untold harm to our patent system and to the industrial progress of our country. Some of the many patent bills now before Congress sadly illustrate the unpreparedness of their happy-go-lucky originators. Our Congressmen and Senators should know that the best anti-trust remedies are those which stimulate individualism and private enterprise and nothing works so strongly to that effect than liberal patent laws provided such laws can be enforced by the patentee of moderate means instead of only serving the interests of wealthy corporations.

Why could this intricate subject of patent reform not be submitted to a commission created by the president? This commission, made up of competent men, should, before suggesting or endorsing reforms, consult with representatives of our national technical and engineering societies, as well as with manufacturers, business men, representatives of the patent office, and lawyers. A resolution to that effect, has recently been addressed to the President of the United States by the Inventors' Guild.

### Symposium On Patent Reform

The last of the joint meetings of this season of the New York Sections of the American Chemical Society, the American Electrochemical Society, and the Society of Chemical Industry was held in the Chemists' Building, New York City, on April 19, and was devoted to a symposium on patent reform.

Three papers were presented, one, entitled "The Inventor, the Public, and the Law," by Mr. Walter F. Rogers, president of the Patent Law Association, of Washington, D. C.; another, entitled "Patents in Their Relation to the Chemical Industry," by Dr. Bernard Herstein, technical expert of the Tariff Board, Washington, D. C., and a third, entitled "The Abuses of Our Patent System," by Dr. L. H. Baekeland, president of the American Institute of Chemical Engineers.

Mr. Rogers discussed at great length the old British patent law and emphasized some differences in the United States patent law. He discussed the existing patent laws of this country on the basis of some important decisions and analyzed the provisions contained in the Oldfield patent bill now before Congress. He advocated the creation of a single court of patent appeals and thought it would be a good thing to systematize the information stored up in the Patent Office.

Dr. Herstein gave in his paper interesting statistics of United States patents relating to the chemical industry, emphasizing the predominance of foreigners in the field. He pointed out that 98 per cent of the German applications for United States patents are assigned to German firms and are not worked in this country. This, he thinks, works decidedly against the development of chemical industry in the United States. He suggested that this should be changed in future.

Dr. Baekeland's paper was considered by many the feature of the evening. It is printed in full on the preceding pages.

In the discussion which followed Dr. Maximilian Toch spoke of the abuses, emphasized by Dr. Herstein, which holds back the development of the chemical industry in this country.

Mr. W. H. Swenarton defended the existing law and practice in this country in general.

Mr. C. F. Carrier, Jr., discussed the troubles of the young inventor who does not know whether a certain field is open or not even if he has a patent, and emphasized that the inventor's title should be made secure before a patent is issued.

Mr. John C. Pennie, in a written communication, called attention to the imminent danger of the passage of harmful legislation by the present Congress.

Dr. Baekeland replied to Mr. Swenarton's defense of existing patent conditions with strong effect.

The meeting lasted almost to midnight.

## Resistivity Determination of Magnesium by Kelvin Double Bridge Method.

By E. F. NORTHRUP.

The object of the measurement was to determine the resistivity and temperature coefficient of a bar of magnesium metal in the temperature range, 20° C. to 155° C.

The precision sought was 1/5 of 1 per cent in the final result.

The sample selected for the measurement was a bar of magnesium which had been accurately shaped in a milling machine to have a rectangular cross-section. Its dimensions were determined with a micrometer caliper and a comparator.

Length of bar over all = 35.60 cms.

Length of bar between potential points = 21.883 cms.

Breadth of bar = 1.412, cms.

Thickness of bar = 1.444, cms.

Cross-section of bar = 2.041, cms<sup>2</sup>.

Weight of entire bar = 78.760 grams.

Density of bar = 1.723.

The potential points were located by drilling two holes in the bar each about 6.8 cms. from an end of the bar. No. 24 brass wire pins were driven in these holes and to these the potential leads were soldered.

The current terminals were fastened to each end of the bar by means of small brass clamps having jaws like a vise. Heavy copper leads were soldered to these brass clamps. As the jaws of the clamps gripped the bar upon opposite sides the current entered the bar so that the stream lines of current very soon became parallel with the length of the bar and were assumed to be almost perfectly so at the potential points.

The chemical analysis of the sample was made by Mr. H. E. Rankin, who reports upon it as follows:

"After the superficial coating of oxide had been removed samples of from forty to fifty grams were taken from the bar of magnesium and submitted to a most careful qualitative and quantitative chemical analysis. No statement can be made as to the absolute accuracy of the determinations since one can never be sure that the impurity sought for is not occluded by the precipitate. However, all precipitates were carefully examined, purified, and in many cases reprecipitations made to insure purity. More than particular attention was paid to the searching for traces of carbon, silicon, chlorine, aluminium, nitrogen, and the oxide dissolved in the metal, since these are the impurities ordinarily found associated with magnesium.\*

The treatment of the metal with nitric acid resulted in a perfectly clear solution with no residue. No traces of impurities could be detected in this solution by the ordinary procedure in qualitative analysis or by special methods. Such a result, however, might be expected, since magnesium can be obtained according to Deville, Caron and Sonstadt in a very pure state by distillation.†

"In the quantitative determinations nitric acid solutions were used. The magnesium was precipitated as magnesium-ammonium phosphate and ignited to the pyrophosphate in which form it was weighed. A searching examination was made of all such precipitates and the solutions from which they were separated. Some comparison determinations were made from hydrochloric acid solutions‡ with practically no difference in the results as shown by the following figures:

Average per cent Mg. in HCl solution..... 100.03%

Average per cent Mg. in HNO<sub>3</sub> solution..... 99.97%

Average per cent of magnesium..... 100.00%

"It seems reasonable, therefore, within the limits of experimental error, to consider the bar of magnesium to be free from all detectable impurities."

The method of measurement was the Kelvin double-ridge method and the apparatus used consisted of the following: A manganin standard resistance (very accurate) of 0.00125 ohm which would carry 200 amperes without appreciable heating. For the proportional arms two 100-ohm coils for the  $a$  and  $\alpha$  resistances, kept fixed, and for the  $b$  and  $\beta$  resistances two plug decade resistance boxes of 10,000 ohms capacity and variable in steps of 1 ohm. The resistance in these latter was varied to secure a balance. The source of current was three small storage cells joined in parallel, and a rheostat held the current at between 10 and 20 amperes. A key was used in the battery circuit. The galvanometer was a Leeds and Northrup H form galvanometer of the suspended-coil D'Arsonval type. It was undamped upon open circuit. Its approximate constants were: Resistance of coil, 550 ohms; complete period, 7 seconds; megohm sensibility, 1 scale division deflection on a scale 1000 scale division; from its mirror with 1 volt and 290 megohms in circuit.

Since it was necessary to accurately regulate and measure the temperature of the bar, a tin trough was provided in which the bar could be placed and kept underneath oil. Paraffin oil

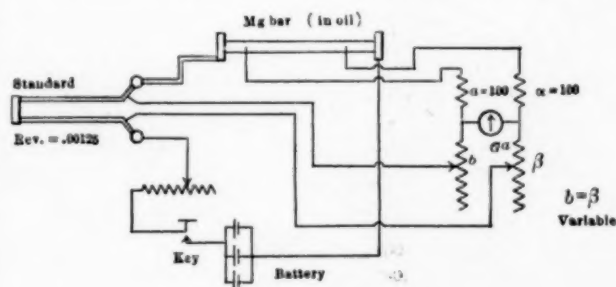


FIG. 1.—DIAGRAM OF CONNECTIONS.

(instead of kerosene to avoid fire risk) was used. In the bottom of the trough was a solenoid of cotton-insulated german silver wire through which current from the 110-volt mains could be passed for the purpose of heating the oil.

The temperatures were read with two accurate mercury thermometers.

The connections employed are given in Fig. 1.

The procedure was first to heat the oil to about 156° C. and to vary the ratio coils,  $b$  and  $\beta$ , until a rough balance was secured. The current was then cut off from the heating coil and the oil was vigorously stirred with a wooden paddle. When the temperature was uniform throughout the tank an accurate balance of the bridge was obtained by varying  $b$  and  $\beta$  together. As the galvanometer was sensitive to changes in the resistances,  $b$ ,  $\beta$ , of less than one ohm, and as these resistances could not be varied in smaller steps the simple plan was adopted of setting the values of  $b$  and  $\beta$  so that, for an exact balance, the oil must cool down a degree or two. Then, at the moment the galvanometer showed no deflection when the key was closed, a reading was taken of the temperature of the oil. This reading of temperature and the setting of  $b$  ( $b = \beta$ ) was recorded. The oil was then allowed to cool a few degrees further, and a new reading was taken with a new setting of  $b$  and  $\beta$ . Altogether 37 readings were taken while the oil cooled from 154.8° to 21.4° C. As the temperature of the oil approaches room temperature the cooling proceeds very slowly and the last few readings were taken at widely separate intervals.

The process might have been hastened by pouring into the can artificially cooled oil.

After the run was finished careful measurements were made of the resistances  $a$  and  $\alpha$ , including the lead wires to redetermine their resistances. They were found to be each 100 ohms within 0.02 per cent, and were called exactly 100 ohms. The following table exhibits the data obtained, together with some obvious deductions.

\*Gmelin Kraut Handbuch der anorg. Chemie II. 2, 369.  
†Compt. Rend. 90, 1027. Jahresbericht. über die Fortschritte der Chemie 1880, 286.  
‡Treadwell Analytical Chemistry, Vol. I, 400.



OBSERVERS A, B, C, NOV. 13, 14 AND 20.				
Temp.	b = $\beta$	Resistivity	Conductivity	Remarks
Degs. C.	Ohms	Ohms $\times 10^{-8}$	Mhos $\times 10^6$	
154.8	1677	6.9522	.14384	Cooling
147.3	1710	6.8174	.14657	started here
139.0	1740	6.7004	.14924	3:07 P. M.
135.8	1760	6.6243	.15096	
132.7	1780	6.5499	.15268	
126.8	1810	6.4413	.15525	3:17 P. M.
119.9	1840	6.3362	.15782	
118.9	1850	6.3020	.15868	
115.1	1870	6.2346	.16040	
109.8	1900	6.1361	.16247	
106.1	1920	6.0723	.16468	
102.8	1940	6.0097	.16640	
99.2	1960	5.9483	.16812	
95.7	1980	5.8881	.16983	
92.0	2000	5.8294	.17155	
88.7	2020	5.7716	.17326	3:27 P. M.
85.6	2040	5.7150	.17498	
82.5	2060	5.6595	.17669	
79.0	2080	5.6056	.17841	3:45 P. M.
76.0	2100	5.5518	.18013	
73.0	2120	5.4994	.18184	
70.1	2140	5.4480	.18355	
67.3	2160	5.3851	.18569	
64.6	2180	5.3480	.18699	
61.7	2200	5.2994	.18870	4:00 P. M.
59.0	2220	5.2518	.19041	
55.5	2250	5.1817	.19299	
52.6	2270	5.1359	.19470	4:20 P. M.
49.6	2290	5.0911	.19642	
47.9	2310	5.0471	.19814	
45.0	2330	5.0037	.19985	
43.0	2350	4.9611	.20157	4:40 P. M.
40.5	2370	4.9192	.20328	
38.1	2390	4.8781	.20500	5:00 P. M.
27.7	2470	4.7030	.21263	6:00 P. M.
21.4	2537	4.5954	.21761	11 A. M. next day
21.9	2532	4.6046	.21718	2:30 P. M.

In column 1 are recorded the temperatures of the oil taken each time after the oil had been vigorously stirred. In column 2 are given the values of  $b$  and  $\beta$ . In column 3 are given the resistances in micro-ohms per centimeter cube. In column 4 are given the reciprocal values of column 3, namely, the conductivity in mega-mhos. In column 5 are made some remarks relating especially to the time of taking the readings.

Various deductions might be made from the above data. Of special interest we note that the resistivity increases very nearly directly as the temperature. We are, therefore, justified in finding the value of the temperature coefficient from the formula,

$$\alpha = \frac{R_T - R_t}{R_t T - R_T} = 0.00418,$$

when we use the temperatures  $t = 21.4^\circ$  and  $T = 154.8^\circ$  and the resistivities corresponding to these temperatures. Applying this coefficient we find

Resistivity of magnesium at  $20^\circ = 4.56 \times 10^{-8}$  ohm

The probable precision of the above results cannot be ascertained from this single determination for unrecognized systematic errors may have entered. As the measurements were made, however, with much care and all the resistances were known to be accurate to better than 1/20 per cent, the presumption is strong that the accuracy of 1/5 per cent, aimed for, has been obtained. It would, however, be unscientific to claim this precision as having been certainly obtained. To give the determination a very high probability of precision, within a specified per cent it would be necessary to repeat the measurements with the dimensions of the specimen changed and with

the use of different ratio coils, standard and thermometer, if any of these were under suspicion. As a matter of fact, this same sample was measured about a year previously, at which time it had not been milled down and its dimensions were greater. A different standard, ratio coils and thermometer were also employed. The value then found for the resistivity at  $20^\circ$  C. was  $4.564 \times 10^{-8}$  ohm.

This differs from the above result by about 0.11 per cent. Thus it may be concluded with a high degree of probability that the value last obtained is correct within 1/5 per cent, the precision sought.

To make the exhibition of the results of the measurements complete, curves giving the relations of resistivity and conductivity, to temperature were plotted upon a large-size sheet of cross-section paper.

In any case where a number of observations are made of two quantities, where one is a function of the other, the most probable relations between the quantities are best exhibited by means of a curve. The curves drawn belonging to the above measurement are not given here because of lack of space.

Palmer Physical Laboratory, Princeton, N. J.

### Magnetic Separation of Zinc Iron Ores as Found in Southwestern Wisconsin.

By OTTO E. RUHOFF.

The object chiefly in view in making the tests to be described was to get further information on the possibility of carrying out a magnetic separation of blende-pyrite ores such as occur in southwestern Wisconsin, without reducing the percentage of sulphur in the tailings to such a point that the buyers of iron pyrite will no longer take them for the manufacture of sulphuric acid. Experiments along similar lines were carried on several years ago by O. L. Kowalke, of the Chemical Engineering Department of the University of Wisconsin, the results of which were published in Vol. 13 of the *Proceedings* of the American Electrochemical Society (this journal, Vol. VI, page 241).

In the present method of magnetic separation, as carried on in the Wisconsin district mentioned, the roast is carried on under strongly oxidizing conditions. The percentage of sulphur in the tailings is usually reduced to between 25 and 30 per cent, while the minimum requirements of acid manufacturers are 35 per cent of sulphur, with preferably 40 per cent or more.

The first method of attack seemed to lie in a substitution of non-oxidizing conditions for the strongly oxidizing conditions at present in use. The iron pyrite would in this way probably be converted to the magnetic sulphide, probably of the composition  $\text{Fe}_3\text{S}_4$ , instead of the magnetic oxide  $\text{Fe}_3\text{O}_4$ . In order to recover still more of the sulphur the most suitable procedure seemed to be to distill off a portion of the sulphur, avoiding the presence of non-condensable gases of any sort in order to avoid the loss of sulphur that these would occasion.

The first step was to determine what conditions of time and temperature were most suitable to get the right kind of a roast. The ore used contained about 18 per cent of zinc, corresponding to 27 per cent of zinc sulphide, so that there were about 70 per cent of iron pyrite present.

In the first tests a small electric tube furnace was used. This had a length of  $13\frac{1}{4}$  in. and the diameter was large enough to take a  $\frac{1}{2}$ -in. quartz tube. The furnace was wound with nichrome ribbon and when used with a 110 volt current had to have a lamp bank in series with it. From 12 to 20 amperes were required to get it up to heat.

A plug of asbestos fiber was placed in the middle of the quartz tube and on one side of this there were placed 50 grams of ore, occupying  $6\frac{1}{4}$  in. On the other side of the asbestos plug a Hoskins couple was placed to determine the temperature.

It was desired to distill off as little sulphur as possible and



still get a magnetic product. In the first two runs difficulty was experienced in watching the distillation of the sulphur, since none of it appeared at the outlet of the tube. All of the sulphur condensed as liquid or solid before it got to the end of the tube. A temperature of about 600 deg. C. was indicated by the pyrometer.

To be better able to observe the evolution of sulphur and to keep it down to a slow rate, a piece of hard glass tubing was next used, and this was drawn out to a point at one end in order that the flame of sulphur might not strike back into the tube. The end of the tube coming outside of the furnace was heated by means of a Bunsen burner so that no sulphur might condense to liquid or solid. In this way it was possible to watch somewhat more closely the course of the distillation. A temperature of 625 deg. C. was maintained for 25 minutes and during this time there was a continuous evolution of sulphur.

Much of the material was strongly magnetic, but there were a considerable number of unaffected particles. It was thought that this might be due to an unequal treatment of the particles, since those nearest the outside of the tube would be likely to get more heat than those in the middle of the tube. Other points that were noted were a certain amount of gluing together of the particles of ore by the sulphur which had condensed in the ore bed during the cooling. Many of the particles were very strongly magnetic and had been converted throughout the grains. The particles seemed to retain their magnetism after the removal of the influence of the magnetic field, a fact which might result in mechanical entanglement in carrying out the magnetic separation.

To insure a more nearly equal treatment of all particles of ore and in order to regulate the distillation still better, all of the succeeding tests were carried out in a small cast-iron drum 5 in. inside diameter and 7 in. long inside. The ends of the drum were closed by cast-iron plates bolted on and removable for filling and emptying the drum. The drum was mounted upon the bearings in such a way that it could be lifted off in order to fill it. A ratchet and pawl arrangement was used to rotate the drum at a rate of one to three revolutions per minute. The drum was surrounded by a sheet-iron insulation lined with asbestos paper, and the upper part of the insulating jacket could be lifted off. Two single and one triple Bunsen burners were found amply sufficient to heat the drum to a bright red which was more than was required at any time.

Pieces of pipe were threaded into the middle of both ends of the drum. One of these was open in order to allow the escape of sulphur vapors and the other extended well into the drum and was closed on the inside end and a Hoskins' couple inside of this served to indicate the temperatures. The drum had two 1-in. angles riveted to the sides in order to promote the tumbling and stirring action within the drum.

In the first test 1060 grams of ore were used. This contained about 3 per cent of moisture. A temperature of about 775 deg. was maintained for 40 minutes, and the weight of the ore after roasting was 860 grams. Much of the ore was found to be decidedly magnetic, but about one-third of the iron particles were practically unconverted. A useful method of determining the percentage of converted particles was that of separating out one size, for example, that between 20 and 40 mesh and examining this under a magnifying glass. If desired this procedure can be carried out on any size using the proper degree of magnification and a fair estimate of the results obtained can be made at once without waiting for the results of analysis.

It seemed possible that the non-uniform roast of the iron particles might be due to insufficient tumbling within the drum. For the next run, therefore, the portion of the pyrometer tube within the drum was removed, so that the inside of the drum was now entirely open and the ore could fall freely. All temperatures after this are approximate, being taken in one shaft,

close up to the drum itself. The temperatures at this point were probably about 25 deg. higher than in the drum.

For the next run 1117 grams of ore were taken and the loss of weight was 85 grams. A temperature of 725 deg. C. had been maintained for 17 minutes. Although a burner was placed under the outlet tube, a portion of the sulphur condensed and it was not possible to observe the rate of evolution closely.

In the next run, therefore, a piece of solid shaft was substituted for the pipe and a 1/8-in. hole provided very close to the drum and connected with the interior of the drum, as an outlet for the sulphur vapors. This made it possible to watch the evolution of sulphur very closely. A temperature of 670 deg. C. was maintained for 48 minutes. In this, as in the previous run, the magnetization of the iron particles was not uniform.

With the idea that it might be necessary to drive off more sulphur in order to make all particles magnetic, a temperature of 660 deg. was maintained for three hours; 1119 grams of ore lost 110 grams during this time. The result obtained was not satisfactory.

It was noticed in all of these tests that the sulphur seemed to come off in puffs and jerks whenever one of the angles came near to the top of the drum, and thus caused a handful of ore to drop to the bottom of the drum. Apparently when the ore has closely approached the decomposition temperature, any slight additional influence, such as the falling of the ore just described, will cause an evolution of sulphur. If as slight an effect as this will cause an evolution of sulphur, it is evident that the tendency to evolve sulphur may vary considerably in different parts of the drum where there are bound to be differences of temperature of 20 deg. or more. Furthermore, if some of the particles have this advantage of 20 deg. or more over others, this condition would remain until the end of the distillation, which would not be the case with reactions brought about by a contact of some gas with ore grains. In this latter case the reaction would become much slower as soon as a surface conversion of the grains that had gotten the first start had been affected, and those getting less heat would have some chance to catch up.

This points to the advantage of bringing about the desired reaction by passing over the ore a current of some gas, such as water vapor or products of combustion, instead of attempting to carry out strictly a distillation treatment. In the next run, therefore, a current of steam was passed through the drum while the heat was being applied; 1184 grams of ore were taken and the temperature was held at 550 deg. C. for two hours. The loss of weight was 57 grams. About 500 cc. of water were evaporated during this time. The vapors given off from the drum seemed to contain  $H_2S$ ,  $SO_2$  and  $SO_3$ , besides undecomposed steam. The ore obtained from this run seemed to be much more uniformly magnetized than in any of the previous runs. This method of treatment would probably be applicable only where considerable quantities of exhaust steam were available.

Another method that seemed to offer a means of securing a more nearly uniform magnetization seemed to be to carry the distillation of sulphur very much further, and to drive off practically all of the sulphur that would come off at such temperatures as had been used in the previous experiments; 1140 grams of ore were used and the temperature was held at 700 deg. C. for one hour, at the end of which time the sulphur had practically stopped coming off. The loss of weight was 216 grams. An attempt was made to catch the sulphur in a 1-in. iron pipe which was again used to provide an outlet for the sulphur vapors. Ninety-seven grams of sulphur were caught in a dish in this way, but a large quantity was lost by dripping upon the floor and by burning.

The ore from this run was extremely magnetic, since probably practically all of it had been converted to the magnetic sulphide  $Fe_3S_4$ . A magnetic separation was made upon a small

portion of the ore, using the size between 20 and 40 mesh. The non-magnetic portion weighed 30.1 grams and contained 62.0 per cent zinc and 1.4 per cent iron. The magnetic portion weighed 51.4 grams and contained 0.6 per cent zinc, 34.0 per cent sulphur and 55.4 per cent iron. This indicates a good recovery of zinc and a good grade of product. It may be assumed that most of the 55.4 per cent of iron was originally in the form of pyrite. From this an estimate can be made of the amount of sulphur that would be boiled off, and this would either be a salable product by itself, or could be mixed with the magnetic tailings containing 34 per cent of sulphur and in this way bring the total sulphur content well up over the minimum requirement. It will be understood that the magnetic separation would not be as good if mixed sizes were worked upon, nor could as much care be used in a large scale separation as was used in this small test.

While the analysis of the products obtained seemed satisfactory, the physical nature of the iron-sulphur product was not what was desired. The particles were extremely friable and most of them could be rubbed to a powder between the fingers. In working on a commercial scale this would probably result in an excessive amount of fines which might be troublesome both in the magnetic separation and later on in the use of the tailings in acid manufacture. It seemed possible that the friable nature of the iron tailings was due to too rapid a rate of distillation and in order to get evidence on this a small crucible full of ore was subjected to as slow a distillation as possible. The cover of the crucible was sealed on with sodium silicate and asbestos cord and a notch cut in one side of the crucible cover to provide one outlet for the vapors, in such a way that the rate of evolution could be closely observed. The crucible was heated in a small electric muffle furnace, and 2¼ hours were taken to complete the distillation. The maximum temperature in the furnace, outside of the crucible, was 840 deg. C. at the end of the distillation period. Much of the sulphur came off at about 725 deg. C. The physical nature of the iron particles seemed to be about the same as before so that apparently the friability results from a complete conversion to

the magnetic sulphide rather than from the rate of distillation used.

It was desired to make some tests using an atmosphere closely analogous to products of combustion as occurring commercially with coal or producer-gas firing. The reason for using these conditions was that there seemed to be a possibility that the roast could be carried out in a furnace of the type of the Wedge, Herreshoff or McDougall, possibly but not necessarily muffle fired, and with a non-oxidizing or at least feebly oxidizing atmosphere in contact with the ore, instead of the strongly oxidizing atmosphere commonly used in the Mathey roasters in Southwestern

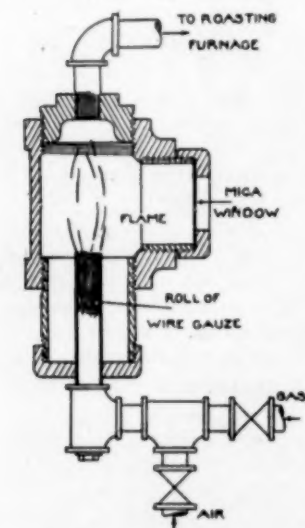


FIG. 1. COMBUSTION APPARATUS.

Wisconsin. The most readily available material was illuminating gas, and in order to get the products of combustion of this and be able to pass them through the small ore drum described an apparatus as shown in Fig. 1 was devised.

The combustion chamber consists of a 2-in. iron tee and the remainder of the apparatus was constructed of suitable iron pipe fittings. A mica window was clamped into the branch of the tee, together with asbestos washers, in order to permit observation of the flame. A roll of wire gauze was tightly

packed into the pipe introducing the combustible mixture into the combustion chamber in order to prevent a striking back of the flame. The gas and air were admitted as shown, and were mixed before entering the combustion chamber. The gas was measured by means of a calorimeter gas-meter and the air was measured by means of a gauge as shown in Fig. 2. This kind of a gauge has been found useful in experimental and other work and will therefore be described. It can be used in cases in which the Venturi-meter or Pitot-tube principle cannot be satisfactorily applied. It is not original with the writer. Two glass tees are connected by means of a piece of capillary tubing, the length and diameter of which will depend upon the amount of gas to be measured, the pressure available, and the percentage of accuracy of reading desired. The branches of the glass tees are connected by means of a U tube containing water, mercury, or any suitable liquid.

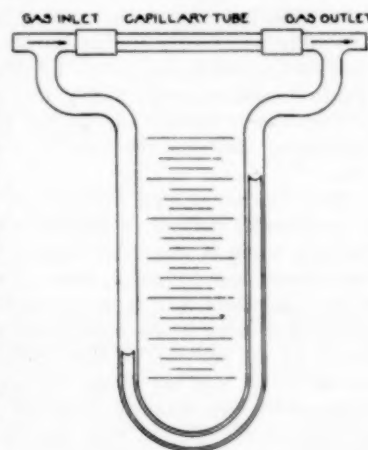


FIG. 2. GAUGE.

With the apparatus as described, products of combustion of widely varying composition could be obtained. If much air was used the flame would have a pale purple color. As the amount of air is reduced or the gas increased the flame first becomes blue and then turns to a yellowish green color. With a very pale purple flame an analysis showed 8.6 per cent  $\text{CO}_2$ , indicating a considerable amount of free oxygen. As the air was reduced the percentage of  $\text{CO}_2$  went up to a maximum of 15.6 per cent. When the air is reduced still more and the green flame appears, the products of combustion contain CO or other combustibles in sufficient quantities so that the gases leaving the combustion apparatus and ready to enter the roasting drum will burn with a very pale blue flame. If too great an excess is used, either of air or illuminating gas, combustion can no longer take place and the flame blows out.

The gases from this combustion apparatus were introduced into the rotating drum previously described, using an asbestos stuffing box. From one roast that was made the following results were obtained after magnetic separation:

Non-magnetic portion:

Weight obtained.....	55.8 grams
Per cent of zinc.....	57.7 per cent
Per cent of iron.....	3.35 per cent

Magnetic portion:

Weight obtained.....	24.6 grams
Per cent of sulphur.....	42.66 per cent
Per cent of zinc.....	1.8 per cent

It is evident that the intensity of the magnet was not adjusted quite strong enough, that is, the grade of zinc ore would have been improved by removing a little more material from it which could readily have been done by adjusting the magnet to a greater strength, and this would probably not have resulted in an undue amount of zinc in the non-magnetic portion. The ore used in this test was a different one to that used in the previously described tests and in this instance all sizes through 10 mesh were treated in the separation.

It was desired to get a rough quantitative idea of the relative degree of magnetization of ore roasted by two different methods. The method used may not be one of the highest accuracy, but is found suitable for the purpose.

A large laboratory balance, not enclosed in a glass case, was used. The scale pans, which were of steel, were removed



and the ore put into a shallow cardboard box about 2 in. x 3 in. and  $\frac{1}{2}$  in. deep. A strong electro magnet was placed directly beneath and in contact with the two flat pieces of brass upon which the scale pan usually rests.

The cardboard box was filled level with ore and weighed. The current was then turned on the electro magnet and additional weights added up to the point at which the magnet would just hold the box full of ore down, and at which an additional  $\frac{1}{10}$  gram would pull the box full of ore away from the magnet when the two were in contact.

The following data were obtained:

	Weight of ore taken, grams.	Apparent weight with current on magnet.	Pull of magnet, grams.
Sample No. 1:			
On 10 mesh.....	107.8	127.4	19.6
10-20 ".....	105.1	118.4	13.3
20-40 ".....	115.5	128.1	12.6
Through 40 mesh.....	115.0	138.7	23.7
Sample No. 2:			
On 10 mesh.....	133.6	136.9	3.3
10-20 ".....	119.0	126.2	7.2
20-40 ".....	110.1	116.1	6.0
Through 40 mesh.....	104.7	108.9	4.2

This table indicates that sample No. 1 is attracted about three times as strongly as sample No. 2. The variation in the attractability of the different sizes of the same ore is due to a variation in the relative quantities of magnetic and non-magnetic material.

A point noted in all of the tests, even in those in which a satisfactory magnetic separation could be made, was a considerable non-uniformity of the degree of magnetization of the particles. Even with particles of almost the same size, and of apparently uniform composition throughout the grain, that is non-chatty particles, the distance at which some particles would be attracted was usually three or four times that at which others would be attracted, indicating a ratio of attractability of 1 to 9 or 1 to 16.

**Conclusion.**—These laboratory tests indicate that, after a light roast in any atmosphere which is not strongly oxidizing, there is every probability that a magnetic separation of zinc-iron ore as occurring in southwestern Wisconsin can be satisfactorily carried out without losing so much sulphur that the iron tailings are no longer of value to acid manufacturers.

This work is not complete at this time and it is not desired to attempt to draw conclusions as to the commercial applicability of the results. It is desired merely to point out what has been observed as to the manner of behavior of zinc-iron ores under the various conditions worked with, and to make note of the apparatus that has been found useful for the experimental work.

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**The great bulk of Mexican sulphur** is produced from mines near Cerritor, in San Luis Potosi, about 50 miles east of the capital of that state. The production is about 800 metric tons of refined sulphur per month. The ore carries from 37 to 90 per cent sulphur, and is refined by the steaming process.

**Transvaal Gold Production.**—The number of companies reporting to the Transvaal Chamber of Mines in January, 1912, was sixty-eight. The total tonnage milled during that period was 2,114,394 tons of ore; 10,068 stamps were in operation with an average duty of 7.92 tons per twenty-four hours. Tube mills in commission numbered 257. The yield for the month was 737,060 fine ounces gold. Compared with the report for the corresponding month of 1911, this report shows an increase of 367 stamps and fifty-five tube mills in operation, and 86,000 fine ounces additional gold recovery.

**The Camp Bird, Ltd.,** owning the Camp Bird mine, Colorado, and the Santa Gertrudis, Mexico, both gold mines, has recently entered the copper mining field by taking an interest in the Messina Development Company, Transvaal, South Africa. Three of the directors of the Camp Bird are directors also of the Messina company.

## The Electric Zinc Smelting Furnace.

BY CHARLES F. JOHNSON.

It has been well said that zinc is a peculiar metal. Its chief peculiarity consists in the fact that the temperature at which zinc oxide is reduced by carbon is over 100 deg. C. above the temperature at which the metal boils. A second peculiarity is the avidity with which this gas takes hold of oxygen in even weak oxidizers as carbon dioxide and water vapor. For these reasons zinc ores are roasted, mixed with carbonaceous material and charged into small fireclay retorts equipped with condensers. Here the oxide is reduced and the emanating gas passes into the condensers and is condensed into metal more or less perfectly.

There are some 90,000 retorts in this country, each with an average daily production of 17 lb. of metal. The natural result is that a high cost of conversion is charged against each ton of spelter. Including metallurgical losses of zinc, lead, copper, gold and silver, the cost of smelting a ton of zinc ore



FIG. 1. TAPPING SPELTER.

ranges from \$20 to \$30. As it takes, on average, over 2.5 tons of ore to make 1 ton of metal the conversion cost, with all charges included, is from 2 cents to 4 cents. The obvious reason is the small unit—the 50-lb. retort.

It is a usual saying among metallurgical engineers that zinc metallurgy has made no progress in the last 100 years. While it is true that there has been progress in the way of regenerative furnaces, mechanical roasting kilns, hydraulically pressed retorts, and in ore-dressing, yet the retort of Abbe Dony still holds sway and there is a large percentage of truth in the part-truth that the metallurgy of zinc has stood still for many past years.

In the metallurgy of lead, copper and iron the cost of treatment has been materially cheapened by enlarging the capacity of furnaces and by instituting labor-saving devices. The cost of treating a ton of copper ore has been so reduced that it is now possible to treat copper ores in the blast-furnace so low in copper content as to be regarded in the nineteenth century as good "dump-slugs."

What modern industrial conditions demand is a unit capable of such expansion in size that the highest-priced labor can be afforded with the result that the work it performs is highly efficient. In 1893 the average copper furnace smelted 50 tons of ore per day. Now 500-ton furnaces are not considered large, and the celebrated Anaconda furnace smelts some 2500



tons of ore. The same increase has been seen in the metallurgy of lead, iron and steel.

Mr. W. McA. Johnson saw in 1903 very clearly that the electric furnace which put the heat inside firebrick exactly where it is needed and where no air could get at it was in view of the above evolutionary tendency the logical way to meet modern demands.

The economic geological conditions he thought then were equally favorable. For a great many years more zinc has been wasted over the dump in form of slag by the lead and copper smelters than has been used as spelter in the mechanic arts. The amount of these so-called refractory ores with a gross value of \$25 to \$40 per ton, now valueless, is enormous in the great mining states. Mr. B. B. Thayer, president of the Anaconda Company, is responsible for the statement that Butte will ultimately be as important a factor in the zinc business as it has been in copper business.\* It is generally considered by well-informed mining men that there are at least \$75,000,000 gross value of these complex sulphides in the upper levels

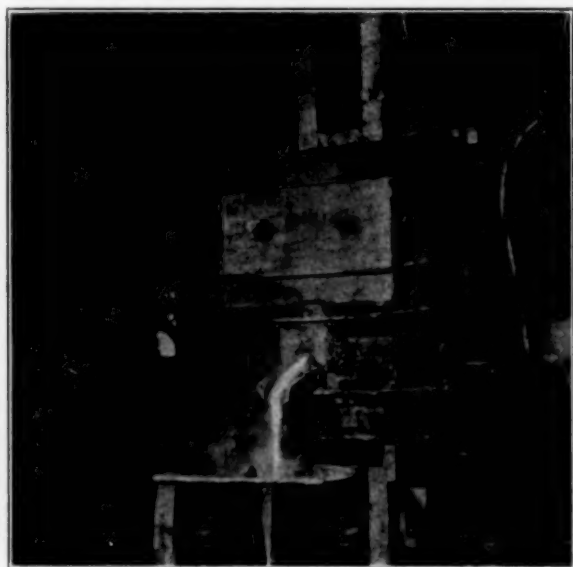


FIG. 2. TAPPING SLAG.

of the Butte Camp. Mr. Johnson's idea has been to make these ores now valueless commercially available by his invention.

Mr. Johnson, as a young man of twenty-six, recognized that the logical solution of the zinc problem was the electric furnace if properly applied and developed. He had especially suitable training, having studied as an electrical engineer and having done some creditable work in that line. He had also studied physical chemistry under Professor Nernst at the University of Göttingen. Undoubtedly the chief factor in his success was his experience under Col. Robert M. Thompson, president of the Oxford Copper Company, investigating new metallurgical processes in the light of practical economics.

Mr. F. E. Drake, who had been engaged in the electrical business previous to becoming in 1903 president of the Lanyon Zinc Company, was impressed favorably with Mr. Johnson's ideas, and Mr. Johnson was engaged as head of the research department of that concern. He finally was put in charge of the No. 2 Works, where he increased greatly the tonnage and recoveries by the application of the principles of physical chemistry.

Simultaneously he was engaged in experiments in electric zinc smelting. The first work was on a reverberatory resistance type furnace. This was early abandoned as impractical.

\*This remark does not refer specifically to any developments in the Johnson process, but rather to expected progress in the general metallurgy of zinc in such classes of ore.

The next move was a resistance furnace with the charge carrying the current. The idea was simply a glorified and improved retort. The earlier furnaces were intermittent, but finally a continuous type of furnace was invented. Most of this work was done with a dry charge and some very good condensation was effected.

In December, 1904, Mr. Johnson left the Lanyon Zinc Company as it was unwilling to go on with the work in electric smelting. Since then he has been giving all possible time and attention to the work of designing furnaces and testing them out with regard to their commercial future.

One of the first ideas was the use of a condenser with a shower of metallic zinc as the condensing agent. This was perfect from a theoretical standpoint, but tests seemed to show it to be less practical than an earlier idea of using a still surface of metal. As the latter scheme gave very positive results and possessed certain decided practical merits, it was co-ordinated with another early furnace wherein the mineral impurities were eliminated as a fusible slag and wherein lead bullion and a copper matte were produced.

This, of course, gave great commercial promise as the lead, copper, gold and silver were recovered necessarily with the elimination of the zinc and it was not necessary to heat up excess of coal. There were certain difficulties, the chief of which were the formation of  $\text{CO}_2$  in the smelting zone. The percentage of  $\text{CO}_2$  that can co-exist with zinc vapor varies with the temperatures according to known laws of physical chemistry. Practically speaking, this results in oxidation during the condensation of the zinc vapor with the production of blue-powder in the condenser, in a furnace that uses no excess of carbon. For the superficial film of zinc oxide on the condensing particles prevents them coalescing. To obviate this Mr. Johnson passes these gases through an electrically heated carbon filter whereby the carbon dioxide is reduced to the innocuous carbon monoxide.

Now it is well known that electrical heat is expensive. An electrical hp-year has almost the same number of calories that a ton of good coal has. Coal costs wholesale from \$1 to \$3 in most well-located centers and in places as high as \$7.50 per ton. An electrical hp-year costs from \$15 to \$40 for a 24-hour load. It will be thus seen that an electrical calorie costs at the cheapest about what twice the most expensive coal calorie costs. Accordingly electrical heat cannot compete with coal heat unless its efficiency is several times greater or unless it has greater convenience and decided metallurgical advantages. Indirect heating by fire gases has at low temperatures a high efficiency (*e. g.*, in boilers, 60 per cent to 70 per cent), but the efficiency decreases rapidly as the temperature increases. To secure a high commercial efficiency it is necessary to utilize the ratio between the dollar and the calorie so that the average commercial usufruct shall be a maximum.

Accordingly the charge in the Johnson process is heated to about 900 deg. C. in a continuous preheater. Then the highly convenient and highly efficient electrical heat completes the work to 1300 deg. C. A heat balance-sheet shows that such an operation under above conditions has thermal requirements of 840,000 calories per 1000 kg of roasted Joplin ore (70 per cent zinc) or 890 kw-hours per short ton of roasted ore. With a low-grade ore (30 per cent zinc) making 25 per cent slag and 16 per cent lead and matte the theoretical net thermal requirements amount to only 436 kw-hours per ton of roasted ore. The Johnson electric zinc furnace will thus probably smelt low-grade zinc ore cheaper than it will high-grade zinc ore. It, therefore, has quite a different bearing on the question of ore concentration methods than has a retort furnace where cost increases as tenor of zinc decreases.

There are several factors, such as losses in busbars, radiation and cost of treating between products such as fowl slag, flue dust and blue powder, that increase the power needed. An estimate of the power needed in commercial units for a 30 per cent. ore is 800 kw-hours per short ton roasted 30 per cent.

and 1400 kw-hours per short ton 70 per cent. roasted ore. The thermal efficiency should be higher in the case of high-grade ore because the strongly endothermic reduction of zinc oxide tends to keep the smelting zinc at a lower and more equitable temperature, or, in other words, to absorb heat more rapidly and efficiently. This has been found to be actually the case in the work at Hartford.

With care in smelting and operating the condenser, and when these are under firm control the much-dreaded blue-powder causes but little trouble in the Johnson furnace. The best record at this writing at Hartford is 390 lb. of metal and 11 lb. of blue-powder. In commercial practice the amount of blue-powder will be proportioned to secure the best economic results, a maximum of condensing output with a minimum of blue-powder. A certain amount of flue dust is made. This is caught in a chamber and returned to the smelting furnace. By running the furnace slowly and carefully this can be reduced to a low figure, but slow running means lower thermal efficiency. Here also the point of proper commercial balance comes in, as it does in condensing, by separating the heavier zinc gas from the lighter carbon monoxide, and as it does in the question of making slags high or low in zinc.

The Johnson electric zinc furnace metallurgically speaking lies between a lead blast-furnace and an iron blast-furnace. This neat comparison was first made by Prof. H. O. Hofman of the Massachusetts Institute of Technology. It makes a slag too low in iron oxide to be fusible at the temperature of the lead furnace and too high in iron oxide to be a good blast-furnace cinder. A typical slag analysis is  $\text{SiO}_2$ , 40%;  $\text{CaO}$ , 22%;  $\text{MgO}$ , 2%;  $\text{FeO}$ , 10%;  $\text{MnO}$ , 1%;  $\text{Al}_2\text{O}_3$ , 10%;  $\text{ZnO}$ , 2%;  $\text{Cu}$ , 0.15%;  $\text{Pb}$ , 0.05%;  $\text{Ag}$ , 0.30 oz. per short ton.

Slags lower than this in zinc, copper and lead have been made, but the above is low enough for a commercial slag.

As in a lead-furnace, the precious metals find their way largely into the lead bullion. If no lead is present, they concentrate in the matte. The composition of this depends on the relative amounts of copper, iron and sulfur. The ore is roasted usually to 3 to 6%, depending on amount of copper present. The general idea is to make as high-grade matte, as far as is consistent with ease of roasting. As the reduction is so much more intense than in a lead furnace the percentage of lead in the matte is much smaller than in the lead furnace. A typical matte analyses:  $\text{Fe}$ , 45%;  $\text{Cu}$ , 25%;  $\text{S}$ , 29%.

The metal made in the Johnson process varies considerably, somewhat according to the amount of lead in the ores, but principally according to the temperature conditions. Metal as low in lead as 0.15% has been made. The usual average is now when working on an ore containing 8%  $\text{Pb}$ , 1.30%  $\text{Pb}$ . The percentage of iron varies from 0.15% to 1.00% as iron is absorbed from the condenser, which is of iron. Speaking generally, there are great commercial possibilities in the manufacture of spelter in electric furnace, suitable for making cartridge brass.

Mr. Johnson and his experts consider that they are now measurably near to the commercial stage. The future problems are those of an engineering nature rather than an inventing nature and his recent results are so consistently good and advance to a present unit of 80 kilowatts from his 40-kilowatt unit accomplished so much that it is thought that advance to a unit of 200 or 300 k.w. will be correspondingly easier.

In the June issue detailed accounts of some of the longer tests, which are now being made, will be given.

Hartford, Conn.

### International Electrical Units.

A report to the International Committee on Electrical Units and Standards by a special technical committee appointed to investigate and report on the concrete standards of the international electrical units and to recommend a value for the

Weston Normal Cell has been prepared under the supervision of Dr. S. W. Stratton, director of the Bureau of Standards, Department of Commerce and Labor.

The International Technical Committee assembled at Washington under the presidency of Dr. Stratton, who is also treasurer of the International Committee.

The committee unanimously elected as chairman Dr. E. B. Rosa, Physicist of the Bureau of Standards, and secretary of the International Committee. Other members are: Dr. W. Jaeger, Geheimer Regierungsrat, Mitglied der Physikalisch-Technischen Reichsanstalt; Prof. F. Laporte, Sous Directeur du Laboratoire Central d'Electricité; Mr. F. E. Smith, principal assistant, National Physical Laboratory, and Dr. F. A. Wolff, associate physicist, Bureau of Standards. Dr. F. W. Grover was appointed secretary for the preparation of the minutes and records.

The committee conducted experimental work at the Bureau of Standards for a period of two months, and carefully considered the results. The conclusions and recommendations are contained in the following resolutions:

(1) The committee decides to choose as the value of the Weston Normal Cell the mean value of the cells presented by the delegates of the four laboratories. This mean was determined in the following way: There was first determined the mean value of the normal cells presented by each delegate, then the mean was taken of the four numbers thus found.

(2) The committee decides to choose, for the present and until there are other mercury ohms prepared, as the value of the international ohm, to be recommended to all countries for general use, the mean of the values of the units realized at the Physikalisch-Technische Reichsanstalt and at the National Physical Laboratory. Although the international ohm as defined by the London Conference has not yet been strictly realized, the committee believes that its value has been attained in two laboratories independently with a good degree of precision, and that future work is not likely to change it by more than 2 or 3 parts in 100,000.

(3) In view of the fact that the mean of the results with the silver voltameter obtained by this committee will probably not be changed by more than a few parts in 100,000, when the specifications are finally completed, the committee decides to recommend to the International Committee on Electrical Units and Standards the following value for the electromotive force of the Weston normal cell:

$$E = 1.0183 \text{ international volts at } 20 \text{ deg. C.}$$

On the subject of the standard cells, the committee is of the opinion that new experiments are necessary before completing or changing the specifications of the London Conference.

On the subject of the ohm, the committee expresses the hope that new international ohms, fulfilling all the specifications of the London Conference, may be realized soon in different laboratories.

On the subject of silver voltameter, the committee is of the opinion that the specifications for the silver voltameter should not be completed until further experiments shall be made by the members of the committee in their respective laboratories on subjects which are not considered settled at the present time, and that after these experiments the committee shall complete the general specifications.

### Peat Gas Producer and Peat Gas Engine.

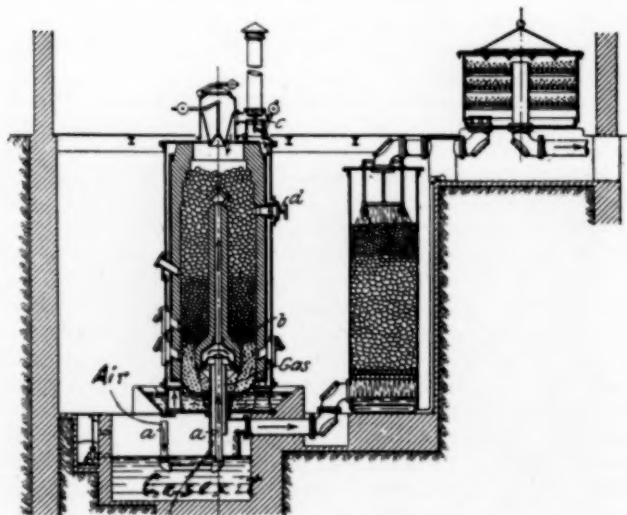
An abstract of a paper of CARL HEINZ giving the following description of a peat gas producer of the Goerlitzer Maschinenbauanstalt and the use of the gas in a peat gas engine, is given in *Stahl und Eisen*, 1911, Aug. 17, p. 1359.

Air and fuel enter the producer at the top and the gas exit is in the center of the bottom so that the air is forced to pass through the center of the producer decomposing the volatile matter into gases of calorific value. The moisture which is



present in the peat fuel in considerable quantities must be taken into consideration. For its decomposition while passing through the hot-fire zone only a certain amount of heat is available. It is, therefore, important that the heat from the gasification be fully utilized.

There are two kinds of heat losses in a gas producer, due to radiation and to the sensible heat of escaping gases. Both these amounts of heat, however, are utilized according to the special design of this producer. The air circulates first through the lower conduit and comes so in contact with the warm scrubber water. A part of the air which has been preheated is carried upwards through the pipe *a* in the center of the producer where



PEAT GAS PRODUCER.

it is thoroughly preheated by the hot gases and enters then the air superheater *b* in which the temperature rises to a still higher degree.

The other part of the air passes through the feet of the producer into an air jacket which envelops the whole shell of the producer and enters finally the producer by the reversing valve *c* on top of the producer. In this way the outer surface of the producer is maintained at a temperature hardly higher than that of the surrounding air. The escaping gases are cooled down so far that the gas outlet into the scrubber may be touched by hand. All ordinary heat losses are thus made use of in the gasification process.

If there is a large excess of moisture in peat, the process is somewhat modified by regulating both air supplies in such a way that the gasification in the upper part of the fuel-bed takes place in two directions, one downwards and the other upwards.

It seems that a content of 80 per cent moisture and 20 per cent dry fuel in the peat is about the limit permitting the evaporation of the water, but it is, of course, impossible to obtain in this case a gas of calorific value.

The modification of the process for very wet fuel is as follows:

When the fire on top of the fuel bed appears to disappear, the heater opens the stack and valve *d*. Valve *c* is then closed, to prevent air from entering on top. The preheated air enters by *d* causing a down draft combustion due to the suction of the gas engine and an upward combustion due to the draft in the stack. The moisture is evaporated and escapes through the stack. When the fire has burned through at the top, the valve is switched over. The bad smelling gases rising from the scrubber enter the producer together with air and are there consumed.

In commercial use at last year's exhibition in Posen the whole plant worked continuously day and night and cleaning of the gas engines was necessary only every three months.

Slagging of ashes is done during the operation of the producer, without any nuisance from dust.

In the same issue of *Stahl und Eisen*, page 1347, there is an illustration of the peat gas engine at the Exhibition just mentioned and some figures are given of the results obtained. The highest percentage of moisture in peat gasified was 50 per cent. The fuel consumption per horsepower hour is 2.2 lb. (1 kg.) of peat. Careful tests made by Prof. Baer, of Breslau, showed that with a cost of peat of \$1 per ton the kw-hour at the switch-board costs 0.15 cent.

R. J. W.

### The Retirement of W. D. Weaver from the Active Editorial Direction of *Electrical World*.

Announcement has just been made of the retirement of Mr. W. D. Weaver from the active editorial direction of *Electrical World*. He will maintain his connection with *Electrical World*, however, as consulting editor.

As a token of the esteem in which he is held, some of his immediate personal friends and his journalistic associates gathered at the Engineers' Club, New York, at a luncheon served on April 29. Mr. James H. McGraw acted as toastmaster. Among the speakers who expressed their sincere appreciation of the honorable editorial career of Mr. Weaver, his advocacy of the best in technical journalism and his helpful constructive influence in electrical engineering development, were his editorial predecessors: Mr. T. C. Martin, Dr. L. Bell, Dr. Carl Her- ing, further Mr. B. A. Behrend, Mr. J. J. Carty, Mr. John R. Dunlap, Mr. W. C. Elgin, Mr. Gano Dunn, and Dr. A. S. McAllister. As a memento of the occasion the associates of Mr. Weaver in the McGraw Publishing Company presented him with an appropriately engraved watch, chain, and fob.

Mr. Weaver is a graduate of the U. S. Naval Academy and served in the navy for 12 years. His career as electrical engineering editor began in 1893, when he became editor of the original *Electrical World*. In 1896 he enlisted the aid of Mr. James H. McGraw in the foundation of the *American Electrician*, of which Mr. Weaver was the first editor. In 1899 when the *Electrical World* and *Electrical Engineer* were consolidated, he became editor of the combined paper, which position he has held continuously up to the present time, the name of the paper having been changed to the present one of *Electrical World* after the absorption of the *American Electrician* in 1896. An interruption in his editorial service occurred during the Spanish-American War, when he served as volunteer chief engineer on the U. S. S. Glacier.

Through the retirement of Mr. Kirchhoff from *Iron Age* and of Mr. Weaver from *Electrical World* in such a short succession, technical journalism has lost two of its strongest and most successful editors.

While little can be said here of Mr. Weaver's literary predilections nor of his fondness for bibliography and his collection of books and publications on the French Revolution, yet a word on the hard work which he has done in the interest of electrochemistry should not be omitted at this place. He was one of the organizers of the American Electrochemical Society and during a number of years, in its early life, served on its Board of Directors and did a great deal of active work in the framing of the constitution and the organization of the society.

When it had been suggested to *Electrical World* to start an electrochemical supplement he saw right away that this would be a wrong policy and that when the psychological moment came the thing to do was to start a specific electrochemical journal. Mr. Weaver interested Mr. McGraw and with their co-operation *Electrochemical Industry* came into existence in 1902. Its editor has always found in Mr. Weaver a good friend, who unhesitatingly extended his aid when needed and gave his advice when asked. This journal cordially joins the many admirers of Mr. Weaver in wishing him godspeed and many years of happiness in the circle of his family and of his friends.



## Boston Meeting American Electrochemical Society.

The twenty-first general meeting of the American Electrochemical Society held in Boston, Mass., from April 18 to 20, may be looked upon as the celebration of the tenth birthday of the society, which was founded on April 3, 1902, in Philadelphia. The Philadelphia meeting ten years ago was so enthusiastic that no seventh son of a seventh son was needed to predict for the society the glorious career which has since become history.

While the society has grown wonderfully in number of members and fields of activity, the Boston meeting showed that the spirit of youthful enthusiasm has remained exactly the same as in the olden days. While ten years ago good-natured, yet sharp controversy centered informally around the ionic dissociation in solutions, it was in Boston the theory of electrons in gases and metals which was discussed and disputed with equal fervor during two long sessions taking a whole day. The symposium on electric conduction, brilliantly arranged by President W. R. WHITNEY, was indeed the most characteristic feature of the Boston meeting.

And the whole meeting was arranged in an equally excellent style, so that the frightful weather during the first two days could not spoil in the least the enjoyment of the meeting in intellectual Boston. The greatest credit for the success is also due to the never-resting and never-tiring secretary of the society, Dr. J. W. RICHARDS; to the strenuous chairman of the committee on papers, Mr. F. A. LIDBURY, and to the local Boston committee, with its always courteous and active chairman, Dr. WILLIAM H. WALKER.

The number of members and guests who registered was 167, and at all professional sessions the attendance was well above 100 and the interest was never lagging.

An alphabetical list of those who registered, as well as an account of the social functions and excursions is given at the end of this report.

### Business Meeting.

The first session was held on Thursday, April 18, in the Chemical Lecture Room of the Lowell Building of the Massachusetts Institute of Technology. The president, Dr. W. R. Whitney, called the meeting to order at 9:45.

The secretary, Dr. J. W. Richards, presented the annual report of the board of directors. The society is in an excellent condition, both as respects to membership and finances. The number of members is now 1,377, the net increase during last year being 110. The assets of the society in cash and bonds on Jan. 1, 1912, amounted to \$5,865.34, as compared with \$4,565.74 a year ago.

A special feature of the report was the announcement that at the meeting of the board of directors the night before, the board appropriated the sum of \$250 for aid of experimental research. If successful this appropriation is intended to be made annually.

The results of the election of officers was then announced as follows:

Dr. W. Lash Miller, of the University of Toronto, is the new president.

Messrs. F. A. Lidbury, E. R. Taylor and L. H. Baekeland were elected vice-presidents.

Messrs. E. F. Roeber, L. E. Saunders and L. Kahlenberg were elected managers.

Dr. Joseph W. Richards was re-elected secretary, and Mr. P. G. Salom treasurer.

### Uniformity and Simplicity in Electrochemical and Electrothermal Calculations.

The first paper in the professional session, which followed the business meeting, was presented by Dr. CARL HERING, of Philadelphia, Pa., on the above subject.

To get uniformity and simplicity in electrochemical calculations, Dr. Hering suggests to use as practical units some decimal multiple of the corresponding absolute unit, following the lead taken by electrical engineers.

His first specific suggestion is to represent all power, no matter in what form it is, in terms of watts or kilowatts and to do away with calories per second, B.t.u.'s per minute, etc.

His second recommendation is to measure all forms of energy in watt-hours, kilowatt-hours, instead of calories, B.t.u.'s, etc. This means that all specific heats, latent heats, "heats" of combination, etc., should be in watt-hours or kilowatt-hours instead of in thermal units, thereby avoiding all conversion factors.

The third recommendation is to adopt as a unit of thermal resistance the "thermal ohm," that is, that resistance which causes 1 watt of heat current to flow when the difference of temperature at its two ends is 1 Centigrade degree. (See the author's paper in our Vol. IX, p. 13, 1911; a table of thermal resistivities of numerous substances in the new unit was given by the author in our January issue of the present Vol. X, p. 43, 1912.)

The author's fourth recommendation is to urge the use of the Centigrade scale to the entire exclusion of the Fahrenheit.

The chief conversion factors to and from the author's simplified system are as follows:

#### Power:

- 1 watt = 0.238882 gram calories per second.
- 1 gram calorie per second = 4.18617 watts.
- 1 watt = 0.0568776 B.t.u. per minute.
- 1 B.t.u. per minute = 17.5816 watts.
- 1 kilowatt = 14.3329 kilogram calories per minute.
- 1 kilogram calorie per minute = 0.0697695 kilowatt.

#### Energy:

- 1 watt-hour = 0.859975 kilogram calorie.
- 1 kilogram calorie = 1.16282 watt-hours.
- 1 watt-hour = 3.41266 B.t.u.
- 1 B.t.u. = 0.293027 watt-hour.

#### Thermal Resistance:

- 1 thermal ohm = 4.18617 gram calorie units of resistance.
- 1 gram calorie unit of resistance = 0.238882 thermal ohm.
- 1 gram calorie unit of resistance = reciprocal gram calorie unit of conductance.

(A gram calorie unit of conductance is a conductance which permits a flow of 1 gram calorie per second per degree.)



W. LASH MILLER, PRESIDENT AMERICAN  
ELECTROCHEMICAL SOCIETY.

*Thermal Resistivity:*

1 thermal ohm, cm. cb. unit = 4.18617 gram. cal., cm. cb. units.

1 gram calorie, cm. cb. unit = 0.238882 thermal ohm, cm. cb. unit.

1 thermal ohm, inch cb. unit = 2.54001 thermal ohm, cm. cb. units.

1 gram calorie, inch cb. unit = 2.54001 gram cal., cm. cb. units.

To reduce thermal conductivities given in B.t.u. per hour, per square foot, per inch thickness, per Fahrenheit degree, to thermal ohm, inch cube units, multiply the reciprocal of that number by 273.013.

In the discussion which followed, Messrs. Griffin, Richards, and Whitney participated. Dr. Whitney said that while the metric system was gaining all the time, yet manufacturers could not be expected to throw away what they have and to go over to the metric system right away. In the meantime it will be well to give in papers all values both in the old and new units.

**Temperature Variations of Thermal Resistivities.**

A second paper, by Dr. CARL HERING, discussed the effects which the variations of thermal resistivities with the temperature have on the calculation of the heat flow through furnace walls. For the purposes of analysis it is necessary to assume some law for this variation. Dr. Hering assumes as an approximate law that the thermal conductivity increases at the rate of  $1/273$  part for every degree C. above 0 deg. C., or in other words, that the thermal conductivity is proportional to the absolute temperature.

If the two sides of a furnace wall are maintained at certain temperatures, the temperature in the wall drops gradually from the inside to the outside and according to the different temperatures the thermal conductivity varies from point to point. Now Dr. Hering shows analytically that it is correct to assume for the whole wall a certain mean resistivity or mean conductivity over the whole range of temperature in the wall and that "the proper mean value of the thermal resistivity or conductivity for the conductor as a whole, is the value for the mean of the two extreme temperatures. The mean of the two extreme values of the resistivity would give a far too high resistance; but for conductivities this mean is correct.

"This applies not only to conductors of uniform section, but also to those that flare like the parts of cubical or spherical shells."

In an addendum it is stated that Dr. Horace Clark Richards has found the following general rules:

"The correct value of the equivalent constant conductivity to use in calculating the resistance of a conductor is the arithmetical mean of its values at the ends, not only for the cases of uniform section and uniform spherical (or cubical) flare, but for a conductor of any form whatever, provided that the surface, except the ends, is insulated.

"The same law is applicable when the conductivity is any linear function of the temperature as  $k = k_0 + at$ , and therefore is the correct approximation when the law is not more exactly known.

"In general, when the conductivity varies with the temperature according to any law, the equivalent conductivity of the conductor is the temperature-average of its conductivities, i.e. if a curve is plotted with temperatures as abscissas and conductivities as ordinates, the proper value is the average ordinate of the curve.

"Of course, all this applies equally to electrical conductivity."

In the discussion which followed, Mr. Fitz Gerald pointed out that while a theoretical discussion of this kind is a useful guide in the designing of furnaces, yet it is necessary to be very cautious about accepting mathematical calculations based on theoretical considerations only, without checking the results by experimental work. He referred to a statement of Que-  
neau: "The great value for heat insulation purposes of silica brick when burned at a moderate temperature, 1050 deg. C., is due to the fact that their coefficient of heat conductivity is

practically equal to that of kieselguhr brick and only one-half that of clay brick." While some silica brick may be good heat insulators, yet this is not general, as shown in Mr. Fitz Gerald's paper abstracted below.

Mr. Fitz Gerald also mentioned an experiment the result of which could hardly have been expected on theoretical grounds. That is that the heat losses of a certain furnace with walls 63 mm. thick were practically the same as the heat losses from the same furnace with walls 126-mm. thick, as long as the temperature was within certain limits. The conditions of this experiment were complicated. There were three factors; radiation, convection, and conduction. The radiating surface with the double walls was, of course, much greater than with the single wall. The probability of losses by convection currents through joints in the bricks were less with the double wall. The temperature gradients, were, of course, different in the two cases. The conductance was seriously modified in the case of the double wall by the resistance of the surface contact between the inner and outer walls and so forth.

In view of these complicated conditions it is unsafe to depend on calculations based on present data, and it is, therefore, necessary to depend on experimental results.

Dr. J. W. Richards referred to the resistivity figures given in Mr. Randolph's paper (see below) and pointed out that the assumption of the thermal conductivity being proportioned to the absolute temperature was fulfilled in the case of one material only.

Dr. W. Lash Miller sketched a very simple and general method of treating the whole mathematical problem with the aid of calculus.

Dr. Carl Hering emphasized the usefulness of fundamental laws. As to Mr. Fitz Gerald's experiment he said that the peculiar result obtained was a combination of internal resistance and surface resistance, and the latter factor seemed to have been of very great importance; it would be desirable to separate the effects of both factors. In the case of steam boilers the thermal resistance is almost entirely a surface resistance; this is the reason why copper and iron give practically equally good results in spite of their different thermal conductivities. For temperature measurements on the furnace surface Dr. Hering suggested the use of graded waxes with known melting points.

Dr. Thwing, referring to the last suggestion, said that by covering the surface with wax the condition of the surface was changed and this would have an effect on the temperature measurement. Dr. Whitney said that waxes had no definite melting points. Dr. Richards thought that easily fusible alloys would be more practical, but Dr. Thwing said that they had no definite melting points either.

Mr. Duschak pointed out that touching a surface with a thermometer may cool the surface and cause an error.

Dr. Richards stated he had found Thwing's radiation pyrometer method very satisfactory down to 100 deg. C.

Mr. Richardson thought melting wax was cheap and so were alloys, but they were of no use for proving fundamental laws. Dr. Hering replied that at present we have practically no experimental data and that any results, even if not of highest accuracy, must be useful.

In reply to a question of Mr. Sadtler how low temperatures could be measured by the radiation pyrometer, Dr. Thwing said that there was no trouble in going low down, but it was necessary to have a sufficiently large surface. The advantageous range of the use of the radiation pyrometer was, of course, the region of higher temperatures.

Dr. Bray suggested for the measurement of the temperature of furnace surfaces the use of thermo-couples, always properly embedded within the surface.

**Experiments on Heat Insulation.**

A paper by Mr. F. A. J. FITZ GERALD, of the Fitz Gerald and Bennie Laboratories, of Niagara Falls, N. Y., gave a pre-



liminary account of an experimental investigation of different heat-insulating materials as to their relative suitability for furnace insulation.

In all experiments the insulating material is in form of bricks and a furnace is always built up from the bricks in the same way (the design and dimensions being given in the paper). The furnace is closed and heated electrically from the inside by means of a nichrome resistance wire. By means of a rheostat the current through the resistance wire and therefore the temperature, can be regulated.

Readings are taken when for a given current a definite temperature has been reached in the furnace and remains perfectly constant. The rate of generation of energy in the resistor is then determined and this gives the rate at which heat is escaping through the furnace walls, neglecting what escapes by conduction through the leads going to the resistor and through the wires of the pyrometer thermo-couple.

From the data obtained in this way curves are plotted in which the abscissas are temperatures and the ordinates watts. These are shown in Fig. 1.

Curve 2 in Fig. 1 is a fire brick of moderately good quality, that is to say, it is not of any special make.

Curve 4 in Fig. 1, is for a silica brick. In spite of its low heat conductivity this particular silica brick is not a satisfactory

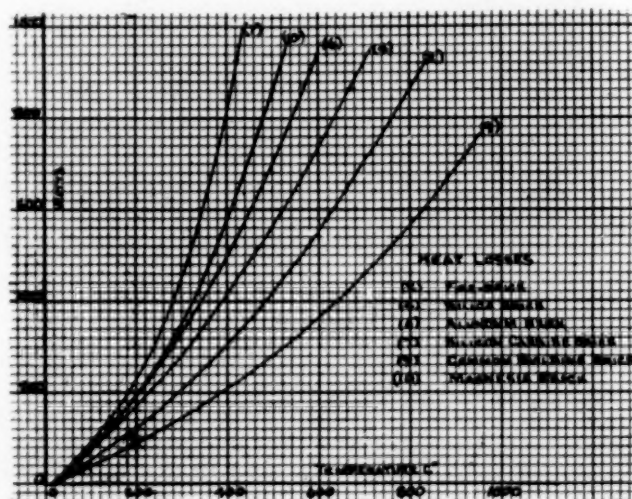


FIG. 1.—HEAT LOSSES WITH DIFFERENT REFRACTORIES.

insulator. The maximum temperature reached with the silica brick was 670 deg. The heat loss here was 36 per cent greater than with the fire brick. It is not very safe to theorize as to the cause of this phenomenon, but it looks as though the radiation from the surface of the silica brick is very much greater than from the ordinary fire brick.

Curve 6 was obtained from an alundum brick, one of the highly refractory ones made by the Norton company. The transmission of heat was so rapid with this brick that the maximum temperature obtained in the furnace was only 570 deg. This illustrates well the value of such alundum refractories as crucibles, muffles, etc., where it is desirable to have as efficient transmission of heat as possible.

Curve 7 relates to a brick made of silicon carbide. The brick is pure silicon carbide, that is, no bond is used in making it. The transmission of heat is extremely good with this brick so that the maximum temperature reached in the furnace was only 420 deg.

Curve 9 is that for an ordinary red building brick of the cheapest kind. It is seen to be the best insulator of any of this lot, the heat losses being as much as 34 per cent less than those for the fire brick (2) at a furnace temperature of 800 deg.

Curve 10 shows the results obtained with a magnesia brick. This was of a standard kind made of brown magnesia.

In another experiment the furnace was built first with the ordinary fire brick (No. 2) and afterwards the same furnace was entirely covered with a 25 mm. (1 inch) thickness of a special heat-insulating material supplied by a well-known manufacturer. This material reduced the heat losses by more than 50 per cent.

Another experiment showed that the use of a special insulating brick instead of ordinary fire brick reduced the heat losses by 68 per cent.

In the discussion which followed, Dr. Hering agreed that empirical data were so much lacking as not to permit furnace design from fundamental laws, but he pointed out that it was necessary to study analytically fundamental laws in order to interpret the results of experimental practice correctly.

Dr. Whitney emphasized that surface resistance was very important and Mr. Fitz Gerald added that heat connection was also very important. Mr. Kohn referred to the effect of packing granular insulating material, for instance, the changes of thermal conductivity when magnesia packs. Mr. Fitz Gerald agreed that the cellular structure was, of course, very important.

#### Thermal Resistivity of Insulating Materials.

A paper on this subject, by Mr. C. P. RANDOLPH, is an account of an investigation carried out in the research laboratory of the General Electric Company. An apparatus is described in detail which was designed for carrying out a large number of thermal-resistivity measurements on compressible materials, such as lampblack, magnesia-asbestos, etc.

The material is pressed between two copper plates, one heated by electricity to the desired temperature, the other cooled by water. The apparatus is described in great detail in the paper and the special advantages claimed for the apparatus are that the contact resistance is eliminated, that the effect of side losses is eliminated, and that no formula for a special geometrical shape has to be used.

A standard compression for powdered and fibrous materials of low density was adopted, viz., the material was packed as much as possible by tapping the thickness measured, and the material then compressed 25 per cent of the thickness it assumed when tapped. Unless otherwise specified, this is the condition which determines the densities given below.

The values of resistivities are given in Table I (p. 288) in "thermal ohms," calculated per inch cube and per cm. cube.

$T$  = temperature of the side at which the heat enters the insulation.

$t$  = temperature of the side at which the heat leaves the insulation.

$A$  = effective area of cross-section in square inches.

$L$  = length (thickness) of insulation in inches.

$W$  = watts.

$D$  = density in grams per cubic centimeter.

$R' = A(T - t) \div (WL)$  — resistivity in "thermal ohms" per cube.

$R$  = resistivity in thermal ohms per centimeter cube.

$R''$  = resistivity in degrees per calorie per second per centimeter cube.

In the discussion which followed Dr. Hering complimented the author on his research, but thought that heat can be measured more accurately and easily as electrical energy than as heat in water as done by the author. An interesting result is the fact that the resistance becomes greater when pulverized material is compressed; the opinion to the contrary is an inherited fallacy. Mr. Skinner spoke on some similar measurements made by him.

#### Temperatures on Silicon Carbide Furnace.

Mr. L. E. SAUNDERS, of the Niagara Falls works of the Norton Company, then presented a paper on temperature measurements on the silicon carbide furnace. There is a com-



TABLE I.—(RANDOLPH'S PAPER).

In the table  $t$  is not given, but was  $2^\circ$  to  $10^\circ$  in every case.  $T$  is given to the nearest hundred.

No.	Material	$D$	$T$	$R$	$R'$	$R''$
1005	85% magnesia-asbestos. This sample was not dried. The measurements were made in the order given. Heating to $600^\circ$ C. has evidently permanently injured the insulation.	0.216	100 200 300 400 500 600 500 400	1475 1508 1503 1513 1430 1425 1205 1295 1343	590 603 601 605 572 570 482 518 537	6195 6332 6313 6353 6006 5985 5061 5439 5639
1008	"Air-cells" asbestos Chars at $300^\circ$ C.	0.250	100 200 300	1092 1008 900	437 403 360	4588 4232 3780
1009	"White asbestos fibre," from Eimer & Amend. Dried at $350^\circ$ C.	0.279	500	1220	488	5124
1006	"White asbestos fibre, acid washed," from Eimer & Amend.	0.201	500	1258	503	5282
1010	"Asbestos wool," from Eimer & Amend.	0.200	500	1100	440	4620
1013	"Long fibre asbestos," from Eimer & Amend. Dried at $350^\circ$ C.	0.293	500	1390	556	5838
1012	Mineral wool from Eimer & Amend. Dried at $350^\circ$ C.	0.427	500	1433	573	6017
1014	Steel wool, No. 2, made by the American Steel Wool Mfg. Co. It is seen that increasing the density 100% increases the resistance only 12%. This material is a good illustration of the fact that it is not the composition that determines the resistance of these materials, but the state of division. The resistivity in this form—as steel wool—is about 700 times that of a steel bar.	0.076 0.101 0.152	100 100 100	1108 1143 1245	443 457 498	4651 4799 5229
1002-1	"Diatmaceous earth and asbestos." This sample was not dried.	0.33	100 200 300 400 500	950 1183 1313 1480 1137	380 473 525 592 455	3990 4967 5513 6216 4778
1002-2	"Diatmaceous earth and asbestos." Dried three days at $300^\circ$ C.	0.33	400 300 200	1443 1345 1370	577 538 548	6059 5649 5754
106-A	"Poplox." Resembles popcorn. Made from $\text{Na}_2\text{SiO}_3$ , by popping.	0.023	200 300	2433 1783	973 713	10217 7487
108-A	"Poplox." Dried at $500^\circ$ C. Resembles popcorn. Made from $\text{Na}_2\text{SiO}_3$ , by popping.	0.093	200 300 400 500	2600 2395 1965 1475	1040 958 786 590	10920 10059 8253 6195
1015-1	"Asbestos fire-felt." This is a very light, but self-sustaining material.	0.116	200 300 400	2205 1493 1258	882 597 503	9261 6269 5282
1016	"Asbestos sponge-felt." Made up of layers about 1/64 inch thick, that resemble asbestos paper. Dried at $150^\circ$ C. before measurement.	0.116	100 200	2550 2208	1020 883	10710 9272
1017	Pure clean woolen fibres. Dried at $100^\circ$ C. The curve, Fig. 4, shows the regularity with which the resistance varies with the density. Of course the density throughout a sample will never be uniform, so that we cannot expect exact proportionality.	0.0153 0.0153 0.0250 0.0352 0.0444 0.0545 0.0823 0.106 0.140 0.163 0.192	80 100 100 100 100 100 100 100 100 100 100	2005 2005 2220 2330 2420 2750 2663 3325 3913 4175 4325	802 802 888 932 968 1100 1065 1330 1565 1670 1730	8421 8421 9324 9786 10164 11550 11184 13965 16433 17535 18165
1018	"Fire roll." This is a heavy cloth about 1/4 inch thick, and is made of pure long-fibre asbestos. Dried at $500^\circ$ C. for twelve hours before testing.	0.575	100 300 500	1218 1243 1223	487 497 489	5114 5219 5135
1007	Cotton.	0.021 0.101	80 100 100	2130 2145 3300	852 858 1320	8946 9009 13860
1019	Eiderdown. Dried at $150^\circ$ C.	0.00214 0.0788 0.109	100 150 150	2133 1558 4063 5075	853 623 1625 2030	8957 6542 17063 21315
1020	Finely ground quartz. Through 200 mesh. Dried at $500^\circ$ C.	1.05	500	383	153	1607
1021	"Granular" quartz. Particles irregular, but about 1/16 inch diameter.	1.64	500	383	153	1607
1022	Coarse quartz. Particles about 1/2 inch in diameter.	1.55	500	333	133	1397
1023	Cabot's No. 5 lampblack.	0.193	100 300 500	3163 2588 2195	1265 1035 878	13283 10868 9219

paratively narrow temperature region within which silicon carbide forms, since below this region it will not form and above it it will decompose.

Experiments on a small laboratory scale have been made before by Tucker and Lampen and on quite an elaborate scale by Gillett. Mr. Saunders' work is particularly interesting as it checks up on a large scale the work done formerly on a small scale. Mr. Saunders' measurements were made on the commercial crystolon furnaces at the Chippawa plant of the Norton Company (crystolon being this company's trade name for silicon carbide).

The only pyrometers available for this purpose are optical and radiation pyrometers, and to determine the temperature of the core of the furnace, where the silicon carbide forms, some means must be adopted to reach that position with fumes or

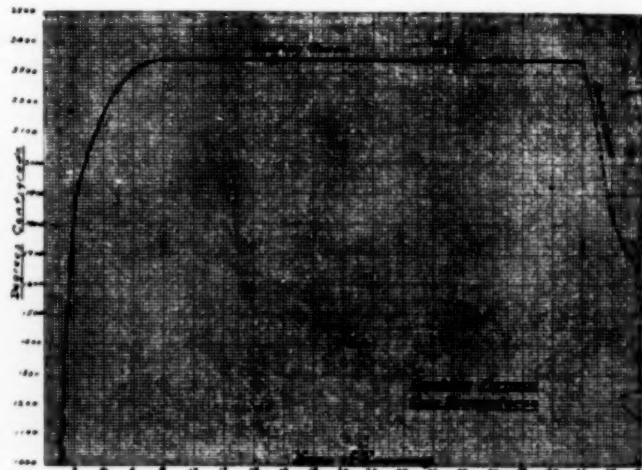


FIG. 2. CURVE OF TEMPERATURES OF SILICON CARBIDE CORE DURING FURNACE RUN

vapors eliminated. A tube at once suggests itself, with some suction appliance for removing or keeping out the fumes with which the interior of this furnace is well supplied (since the fumes would seriously interfere with the temperature readings). Gillett used a tube, made of silicon carbide, with a double wall, one end closed with a graphite disc, this end being placed against the silicon carbide core on the side, the other end projecting through the brick walls of the furnace.

Mr. Saunders, in working on a much larger scale, encountered many difficulties with the tube construction. The greater distances to cover, the settling of the charge, and the longer time of running, necessitate tubes of comparatively great length and strength, and of high resistance to thermal and oxidizing conditions. Mr. Saunders was forced to use amorphous carbon tubes. For taking temperature measurements, he used a Thwing radiation pyrometer.

Turning now to the experiments, readings were first attempted at the graphite disc next the core throughout a furnace run. The curve, Fig. 2, is typical of the results obtained. It will be noted that the temperature increment is rapid, but the readings at the lower points were shown to be low by means of an additional single tube inserted beside the other, with a small hole through which the heating of the core was observed. The difference in temperature between the inside and outside of the graphite disc lessens rapidly as the core heats up and as Gillett has shown the permanent heat lag becomes small at points above  $2,000^\circ$  C., and after the run has continued for some hours.

Changes in core area, or in other words changing the rate of energy developed per square mm. of core area, has had less effect than was expected on the core temperature. With areas varying as much as 5 per cent the variation from the average in the maximum temperature reached has not been more than

50 deg. C., although as was expected the larger core areas gave the lower temperatures.

In addition to reading temperatures at the core, numerous readings have been taken at various distances out through the furnace charge. This was done with a separate graphite disc, slightly smaller than the inner diameter of the tube, which was attached to a thin carbon rod, by means of which it was moved to the desired position. With this appliance the author was able to determine the points at which fire-sand begins to form, at which crystalline silicon carbide forms, and at what temperature it decomposes into its constituent elements.

The results of the measurements of the author together with those of former investigators are given in table II.

TABLE II.—TEMPERATURES IN SILICON CARBIDE FURNACE.

Observers	Fire-sand (Limits)		Crystalline Silicon Carbide (Limits)	
	Formation °C.	Decomposition into Crystalline SiC	Formation °C.	Decomposition into C and Si
Tucker and Lampen, 1906	1650	1950	1950	2220
Same, corrected by Gillett	1500	1830	1830	2220
Gillett, 1911	1540 ± 30	1820 ± 20	1820 ± 20	2220 ± 20
Saunders, 1912	1600 ± 50	1840 ± 30	1840 ± 30	2240 ± 5

In the discussion which followed, Dr. Bancroft pointed out the identities and differences between large-scale and small-scale working. There is absolute identity with respect to the results of the temperature measurements, while there are necessarily considerable differences in the methods of measurements. Messrs. Amberg, Lidbury, Burgess, Thwing, Whitney and Tucker also participated in the discussion.

Dr. Richards spoke of the way in which carborundum crystals are formed. They are due to the two vapors of silica and carbon coming together. Dr. Whitney suggested the possibility of silicon vapors instead of silica vapors.

#### Furnace Electrodes Practically Considered.

A paper on this subject, by Mr. R. TURNBULL, of Electro Metals, Ltd., Welland, Ontario, was read in the author's absence by Mr. Fitz Gerald.

Mr. Turnbull considers amorphous carbon electrodes only. The mixture used in its manufacture is anything but a complicated one, being simply one kind of carbon mixed with certain percentages of pitch and tar. This, after being well mixed together, is moulded in some special apparatus to the desired form and then baked in a furnace in a non-oxidizing atmosphere. Good electrodes were made from the beginning, but the trouble was that not all electrodes made were equally good. "Electrodes made at the same time, under the same conditions, and baked in the same furnace, have shown in actual service as many different characteristics in quality as could well be imagined, some giving excellent service whilst others simply went to pieces after being in operation for a few minutes."

Mr. Turnbull thinks the main cause of failure was the use of the wrong carbon material. In the early stages of electrode manufacture petroleum coke was mostly employed. But it did not work well, as electrodes made from it crumbled to pieces in the furnaces. Better results were then obtained by the use of retort carbon, a kind of coke deposited in the retorts in gas works, being nearly pure carbon. But as the retort carbon had to be collected from gas works all over the world a homogeneous article could not be counted upon, and this made its use dangerous to the manufacturer, so far as reliability was concerned.

It was only when anthracite coal came into use that real progress was made, and the best kind of electrodes in use today are made from this material.

We are indebted today to the Plania Werke for the moulded screw, which enables electrodes to be joined together, thus doing away with the stub and machining of the electrode and the trouble of changing electrodes in the furnace. This screwed electrode applies mainly to furnaces for the manufacture and

refining of steel. At the present time nearly all manufacturers are using anthracite coal as the carbon base, and while electrodes made by some manufacturers are superior to those made by others, this is mainly due to the different methods of moulding the electrodes and preparing the coal employed.

So much progress has been made in this industry in the last two or three years that perfectly satisfactory electrodes up to 24 inches (60 cm.) in diameter and 7 feet (2.1 m.) long are now being made, whilst only a few years ago nothing over 12 inches (30 cm.) square and 5 feet (1.5 m.) long was satisfactory. No doubt still larger electrodes can and will be built, as electric furnaces are still growing in size, and the time is not far distant when steel furnaces of 30 tons' capacity, and operating with electrodes 3 feet (0.9 m.) in diameter, will be as common as are our small 5-ton furnaces of today.

As to the use of electrodes in furnaces Mr. Turnbull gives the following hints: In order to avoid all losses to the greatest extent possible the current should enter the electrode at a point as near as possible to the point where it will leave it. It is quite common practice to connect the metallic conductor to the head of the electrode, but this is a grave mistake, as the loss in volts in a long electrode will be from 4 to 6, depending on the current density employed, and in a furnace where the operating voltage is 50 volts, this loss would be equal to from 8 to 12 per cent of the total energy consumed.

Electrodes should be held in the same manner as one would hold a bar vertically in the hand, so that they can be taken at any point on their length, and in smelting furnaces the holder giving contact to the electrode should not be at any time more than 1 foot (30 cm.) above the charge. As the electrode wears away it is slipped through the holder, and the process goes on until it is finally taken by the head, but at no time should the part of the electrode carrying the current project more than 2 to 6 inches (5 to 15 cm.) from the holder itself.

The losses, both of heat and energy, can be decreased by increasing the size of the electrode, but this can be carried too far. Mr. Turnbull recommends a current density of from 30 to 35 amperes to the square inch of section (5 to 6 per sq. cm.) in order to keep the electrode as cool as possible and thereby prevent side oxidation and heat losses. With too large an electrode, quite a good percentage of the total energy supplied to the furnace would be required to keep the electrode warm.

An important point, the value of which is sometimes overlooked when considering the size of electrodes, is that it is often advisable to use electrodes of greater cross-section than electrical necessity demands, but for a totally different reason. In some processes, for instance, the electrode when working is surrounded to a certain depth by charge mixture. At the surface of such charge mixture, and therefore at some distance from the working end of the electrode, inflammable gases are given off, and these burning in air tend to attack and consume the electrode. Thus there is a tendency to reduced cross-section at this point with consequent increased current density, followed by rise of temperature, which further aggravates the condition described. It is, therefore, wise, for convenience sake, to use a larger cross-section so that the burning away does not result in eating the electrode through, letting a large piece of electrode into the charge and disturbing conditions generally. This is one of the exigencies imposed by practice.

In reply to a question of Dr. Hering, Mr. Fitz Gerald described a case in which evidences of the skin effect in an electrode were found.

#### Gas Circulation in Electric Pig Iron Furnaces.

A paper, by Dr. JOS. W. RICHARDS, of Lehigh University, dealt with "gas circulation in electric reduction furnaces" as practiced at the Joernkontoret's electric pig iron furnace in Trollhättan (see Mr. Leffler's report in our vol. IX., pp. 368 450, 505, also page 631). As described before, this circulation of gases is chiefly employed for the purpose of cooling the roof of the crucible.



Dr. Richards points out that the advantages of this cooling system are offset by serious disadvantages. He recommends that the artificial circulation of the gas should be entirely dispensed with. The arch of the crucible of the furnace should be protected by water-cooled plates, as is common in open-hearth furnaces.

Among other recommendations made by Dr. Richards on the method of working at the Joernkontoret furnace is one to the effect that the limestone flux should be calcined before putting into the furnace.

Further the shaft of the furnace should be provided with auxiliary heating to maintain its contents at or above 400 deg. C., to permit of reduction of  $\text{Fe}_2\text{O}_3$  by the slow current of CO gas.

Under these conditions an amount of carbon equal to one-fifth of the weight of iron produced should be sufficient, producing gas containing two volumes of  $\text{CO}_2$  to one of CO.

Eliminating the expense of circulating and purifying the gas, and reducing the amount of fuel required for reduction, would both simplify and cheapen the operation of the furnace in Dr. Richards' opinion.

There were several communicated discussions of this paper, one by Mr. Leffler of Sweden, and another by Mr. Noble of the Noble Electric Steel Company of California. Mr. Leffler wrote that if the artificial gas circulation could be dispensed with, nobody would like it better than those who have to run the furnace. Mr. Noble stated that in their electric pig iron furnace in California only calcined limestone is used as flux and no artificial gas circulation.

#### High-Tension Equipment for Electrochemical Plants.

A paper on this subject was presented by Mr. J. RATTRAY WILSON, of Niagara Falls, N. Y. The high-tension part of the electrical equipment of electro-chemical plants is now practically standard, the chief requirements being foolproofness and easy accessibility.

In the vicinity of Niagara Falls the primary current is delivered at a tension of 11,000 and 12,000 volts, and until recently it was all brought to the consumer's premises on overhead cables. On the American side this overhead construction is largely being done away with, the conduit system taking its place. This alteration saves a great deal of trouble, as it eliminates to a very large extent the heavy surging from lightning or other external causes. It is more expensive to construct, but no doubt it will pay in the end.

In bringing in the overhead power cables the author has made it a rule to have these about 20 feet (6 m.) above the ground, 18 feet (5.4 m.) being a minimum. The author prefers to build a special intake tower for this purpose, containing all the incoming switches, lightning arrestors, main circuit breakers and necessary meters. This tower can be located where convenient, but it ought to be as central as possible.

The author gives considerable details of wiring and of the protection devices employed. He emphasizes that the main oil circuit-breaker must be a heavy one and the best is none too good.

In connection with the transformer installation the use of a water rheostat, placed between the disconnecting switches and the transformers, is interesting; a special, single-pole, oil circuit-breaker being used to short-circuit. Where transformers have to be started under full load, this rheostat is of great importance.

In the first place, it is impossible to determine which phase the transformer circuit was opened on, and consequently when starting it may be closed on a reversal of magnetism, thus causing a dead-short-circuit, so to speak. Secondly, when closing in on, or near, the top of a wave, surging is sure to follow, and it is no uncommon thing to find the circuit-breaker coming out four or five times in succession. Thirdly, closing a transformer circuit under full load will cause severe stresses in any case. The transformer builders recognize this, and now build choke-

coils in the case, along with the other parts. Although this helps to a large extent, it is not adequate in all cases.

The effect of a long column of water acting as a resistance allows the transformer to pull into step, as it were, without undue stress. In starting a 750 k. w. transformer, with 12,000 volts on the primary, under the most severe working conditions the author could devise, the immediate starting current never exceeded one-sixth of the normal working current. The construction of this rheostat is very simple. Two wooden tanks are made and set up on petticoat insulators, supported on either a wood or a pipe frame. A loop from one of the poles is cut, one end brought through the bottom of one tank, and the other through the bottom of the other. These cables terminate in cast-iron discs. The closing mechanism is a copper rod of suitable cross-section, fixed to but insulated from a wood bar, the wood bar being capable of being raised or lowered, and kept in position by sliding in grooves. To the ends of the copper rod are fixed cast-iron balls to give surface for the current to pass to or from the water, also to act as contact or arcing pieces, in conjunction with the metal discs mentioned above. Both the discs and the balls are screwed onto copper rods so as to be easily replaced if necessary, the rods to the discs passing through stuffing boxes on the under side of the tanks. The movable rod is bent "U" shaped so that the vertical portions are coincident with the vertical axes of the tanks. This rod is raised or lowered by a rope, leading through pulleys to a winch placed in a convenient position in the low-tension room.

The method of operation is as follows: The oil circuit-breaker is closed on one pole, the copper rod is next lowered slowly till it makes contact, then the short-circuiting switch is closed, thus closing the other pole; the rod is then raised to the top of its run ready for another occasion. The rheostat may be used for breaking circuit provided the column of water is long enough, but it is very much better practice to use the oil circuit-breaker, which is designed for this purpose, as the stress which may be set up by the change of frequency due to the arc being maintained on the top of the water may cause troubles of its own.

In a communicated discussion Mr. J. L. Harper explained in detail why at the present time it is believed to represent good judgment, in all except long overhead lines, to consider most protective devices as causing more trouble than they are worth, to make a study of the factory ends of the distributing lines in order to produce a minimum of fluctuations, surges or unbalancing conditions, and to develop and use, both in the central station and at the receiving end of the lines, switches having a capacity commensurate with the whole capacity of the generating plant back of them.

#### Power Supply to Electric Furnaces.

In a paper on "power supply to electric furnaces for refining iron and steel," Mr. W. SYKES, of the Westinghouse Electric & Mfg. Co., pointed out that while pretty soon a large industrial development is to be expected in the installation of electric furnaces in the steel industry, it will first be necessary to modify certain features of construction.

Are furnaces of 15-ton capacity are now in operation, using the electrodes. On account of the difficulties of building very large electrodes, the author thinks that in designing furnaces of say 30 to 50 tons capacity two or more sets of electrodes will be adopted. This will complicate to some extent the construction and "considerable development will be undoubtedly necessary to satisfactorily handle the numerous electrodes." A furnace with six electrodes has already been built and is in operation.

The author doubts whether furnaces of more than 30 tons are necessary or desirable. The handling of currents even of 12,000 amperes presents considerable difficulty, not only from the standpoint of conduction, but also on account of the effect of the self-induction of the leads on the power factor of the equipment.

The reactance must be limited as much as possible, and an



examination of existing furnaces shows that considerable trouble has been taken by interlacing the conductors to reduce the self induction. It is probable, however, that before handling larger currents some structural changes will be necessary to avoid running the conductors close to iron supports, etc., and also to reduce their length.

When a large number of furnaces are used at one plant, the effect of the variations in current during operation would not be very great, and it is only when considering small installations that particular attention need be given to this feature.

In the case of a single furnace, provision must be made in the power house to take care of short circuits in the furnace, since they are unavoidable. The frequency of these short circuits is dependent upon the regulating mechanism of the furnaces, which is one of the details that must be given more attention in the future than in the past.

In discussing the induction type of furnace, the author points out the difficulties of getting a reasonably high power factor and the advantages obtained by combining the induction with the resistance type in the Roehling-Rodenhauser furnace.

When considering a new station for the operation of induction furnaces, it would undoubtedly be cheaper to install generators with a large kilo-volt-ampere capacity compared with the size of the prime movers. The cheapest way to take care of the wattless component is undoubtedly to increase the size of the generators. If the generating plant is already installed, it is necessary to provide other means for accomplishing the same purpose, and in general two methods are available; one is to use a motor generator set either with a low-frequency generator, or one of large K.-V.-A. capacity, and the other to use a synchronous condenser which will compensate for the low power-factor of the furnace.

Comparative cost curves given by the author for both arrangements, show that there is a very appreciable saving in the first cost (something like 50 per cent) in the use of the synchronous condenser, for which there is also a saving of 6 or 7 per cent in power. Hence when furnaces are installed on existing power stations and trouble is caused by low power-factor, the proper arrangement is to install a synchronous condenser instead of a motor-generator set. In the case of frequencies higher than 25 cycles this also holds good, although with 60 cycles the saving is somewhat less.

The use of the resistance type of furnace for steel refining has been limited to very small sizes, on account of the difficulty of handling the very large current necessary. The author illustrates this by a numerical example.

The author adds a note on the electric pig iron furnace and he discusses the problem of power generation. Of course, water power would be cheapest, but there are also possibilities of producing power from coal cheaply and gas power is also available. But, after all, the cost of power is by no means the principal item in the expense of electrically refining steel, and quite as much, if not more, can be accomplished in the reduction in the cost of production by reducing the consumption of electrodes, linings, etc., as by reducing the power cost.

#### Electric Furnaces for Heating Bars and Billets.

Mr. THADDEUS F. BAILY, of the Electric Furnace Company, of Alliance, Ohio, gave an account of further developments of his electric furnace for heating bars and billets, which was described in our vol IX, p. 262 (May, 1911).

A chrome lining in his furnace proved unsatisfactory. Silica brick and Grecian magnesite brick with ground magnesite proved satisfactory and magnesite was even better than silica. Magnesite was, therefore, chosen for the final furnace.

The dimensions of this furnace were 56 in. (140 cm.) wide, 45 in. (113 cm.) front to back and 42 in. (130 cm.) high, and it was designed for 60 kw. current consumption when heating 240 pounds (109 kg.) of metal per hour. The wall loss was calculated at 30 kw. per hour. These figures checked very closely, as the wall loss with a ruling temperature of 2650 deg.

F. (1455 deg. C.) was 28 kw. and the metal heated was 280 pounds (127 kg.) with 66 kw. in one hour's time, this giving a figure of 4 pounds (1.73 kg.) of metal per kw. hour. The metal was raised from a temperature of 50 deg. F. (10 deg. C.) to 2350 deg. F. (1288 deg. C.). Under the above conditions the furnace had a thermal efficiency of approximately 50 per cent.

The voltage of this furnace was entirely satisfactory; from a starting voltage of 150 volts the voltage was rapidly reduced to 60 volts, the current flowing at this voltage with a temperature of 2650 deg. F. (1454 deg. C.) was 1,000 amperes, with power factor 0.98. This current and temperature condition was maintained for hours at a time when heating metal. When no metal was being heated, the current was reduced to 46 volts, 600 amperes, with power factor 0.98, and the temperature in the furnace maintained at 2650 deg. F. (1454 deg. C.).

When this furnace had been run for 13 days, the top was removed and the interior inspected, and the following observations noted:

The contact between the resistance body and the electrodes was perfect, there being no arcing or trouble of any kind.

The contact between the electrodes, which were 4 x 4 in. (10 x 10 cm.) carbon, and the standard feeder-cables was made with bronze clamps and Dossert cable-lugs, and gave no trouble whatever.

A tendency of the electrodes to burn at the point of entering the furnace walls was corrected by using two 3-in. (7.3 cm.) round electrodes in place of one 4-in. (10-cm.) square, and placing a sheet iron sleeve over the outer end of these electrodes to a point at least 8 in. (20 cm.) inside the furnace walls. The clamps were then placed over the sleeve and electric connection made from clamp to electrode, the current going through this protecting sleeve. This arrangement effectually prevented the oxidation of the electrodes at this point.

The electrodes in contact with the resistance material showed no reduction in size whatever—in fact, were of slightly increased size, owing to particles of the carbon resistance material adhering to the electrodes.

The coke or resistance material, composed of  $\frac{1}{2}$  to  $\frac{3}{4}$  in. (0.6 to 0.9 cm.) crushed coke, was completely converted into graphite, and lay in a compact though not hard mass in the core of the furnace.

The Grecian magnesite lining had eroded to a depth of about 1 in. (2.5 cm.) on sides and bottom, where in contact with the coke, but had not fluxed with the coke at all. This lining was then repaired by adding a 2-in. (5-cm.) layer of Grecian magnesite, mixed with water, so that it would hold to place until the resistance material was put in. On heating the furnace to temperature this magnesite cindered into place without trouble. Since this repairing, the furnace has run about 30 days with great regularity, and the linings are apparently in excellent condition.

The cost of the magnesite for such repairing as noted above was about \$2, and required about 3 hours' time for one man to do the work. This low cost of repairs was exceedingly gratifying as compared with the high cost of refractory repairs in oil furnaces.

The data given in table III. was taken from a typical test sheet showing the current conditions and metal heated during a given period:

TABLE III.

Temperature of interior at charging.....	2615° F. (1425° C.)
Temperature of interior at withdrawing.....	2600° F. (1426° C.)
Voltage of furnace.....	60
Amperage of furnace.....	1150
Power factor.....	0.99
Indicated kilowatts.....	69
Amount of metal charged, being 8 bars.....	92 pounds (41.7 kg.)
1½ in. (3.8 cm.) square by 18 in. (45 cm.) long }	
Time in furnace.....	20 minutes
Temperature of metal, when charged.....	60° F. (15° C.)
Temperature of metal, when withdrawn.....	2360° F. (1239° C.)
Kilowatt hours consumed in heating metal.....	23
Pounds (kg.) of metal per kilowatt hour.....	4 pounds (1.73 kg.)
Kilowatt hours per ton of metal heated.....	500
Capacity of furnace, per hour.....	276 pounds (125 kg.)

In the discussion which followed, Dr. Richards expressed the opinion that by improved design and better insulation the efficiency of the furnace might still be raised quite considerably.

#### Electric Conduction in Gases.

The special feature of the Boston meeting was the symposium on electric conduction. It consumed the whole day of Friday.

As a preliminary introduction an illustrated experimental lecture was delivered by Prof. CHAS. R. CROSS in the Physics Lecture Room of the Walker Building of the Massachusetts Institute of Technology. The lecture was devoted to demonstrations of electrical discharges in high vacua and the demonstrations were really brilliant. They illustrated the evolution of our knowledge of electric conduction through rarified gases.

#### Presidential Address.

The presidential address of Dr. W. R. WHITNEY, the director of the Research Laboratory of the General Electric Company, of Schenectady, was intended as an introduction to the symposium on conductance which followed. Dr. Whitney pointed out that we are in the midst of a period of great advance in our conceptions of electric phenomena and that a knowledge gained in any of the separate fields such as, for example, a vacuum tube, is becoming applicable to other fields like open-air arcs or even metals. The ions and electrons are no longer the property of a small group of pure physicists, but are rapidly becoming the alpha and beta of electrochemistry in general.

The object of Dr. Whitney's address was to recall and emphasize some simple general facts of electric conductivity. But he was impressed with the thought that some of the simplest facts are often very interesting, and whatever ideas or theories of conduction are advocated, they must first serve to cover and clothe such simple facts.

The bare fact that electrical conductivity of pure metals increases with falling temperature at approximately the same rate for all the metals must be of the utmost importance to a further understanding of the phenomena of conductivity.

That the temperature coefficient of resistivity of metals is about the same as that for the expansion of gases has undoubtedly led to the attempts to apply gas laws to the conducting ions in metals. Just as we cannot obtain gases of appreciably higher expansion coefficient than 0.0037 by any system of mixing them, so also we fail by alloying the metals to get any alloy having a higher resistance coefficient than this value. Magnetic metals, such as iron and nickel, have a somewhat higher coefficient because of the inductive effect, but this irregularity is, we are told, in turn a support of the ionic theory of conduction.

Dr. Whitney reviewed the researches on metallic conductivity at low temperatures which have led to the conclusion that the electric specific resistance of all pure metals vanishes at the absolute zero of temperature. But this is only true for metals since the resistance of alloys in general does not disappear at zero. This in turn is another fundamental fact which new conduction theories must cover.

Another fundamental fact is the apparently general rule that there seem to be no ductile poor conductors. The pure metals or those pure elements which can be obtained in wire form, for example, all possess high conductivities comprised within a rather narrow zone.

While these are interesting scientific facts they have also opened possibilities from an engineering view point. An instance are the schemes for cooling long-distance transmission lines by liquid air.

Dr. Whitney then reviewed the resistivity of alloys, chiefly following the generalizations of Guertler. As a first general approximation, the alloys of metal-pairs may be divided into two classes: those which exhibit conductivity at least approximately calculable from the conductivities of the components. For example, any alloy of lead and tin conducts about as the

two quantities of the components would if placed side by side. This applies to alloys between lead, tin, zinc and cadmium.

There is another class of alloys which at certain compositions are simple chemical compounds, such as  $\text{Cu}_2\text{Sb}$ ,  $\text{Cu}_3\text{Sn}$ , etc. These have conductivities not apparently to be predicted at all from the conductivities of the components. This corresponds to the cases of melting-points of alloys which latter follow in some case quite simple general rules, but which do not permit of prediction of the melting-point of a compound when one is formed between the two metals.

Between the compounds of metals and either of the metals themselves mixtures are possible whose conductivity will be like that of the simple mixtures of lead, tin, etc.; that is, they will be calculable from the volume-concentration of the two components, when the metal compound is considered as one component, and so also when two metals form two different compounds these two may act in turn like the single metals, lead and tin.

There is another feature which involves the crystallization-condition of the alloys on cooling from molten state. In the case of the lead-tin or the simple group, the metals crystallize out pure, just as salt or ice may separate from an aqueous solution, but in other cases the freezing microscopic crystal is itself a mixture and the composition may change with the liquid concentrations, so that the resistance of the final solid is no longer calculable from the resistance of the components. To this class belong those cases in which a very small quantity of an added element causes a very great increase in resistivity. Guertler has pointed out that this electrical difference between the compound and the mixed crystal, lies in the fact that even a very small quantity of foreign element in the mixed crystal very greatly interferes with conductivity, while the pure compound of the elements is homogeneous and has a maximum conductivity, just as the pure element has.

The fact that the presence of certain impurities in very small amounts in materials like copper and iron affects their properties to a great extent is of great importance to the engineer. Even so small a quantity of arsenic as one-tenth of 1 per cent reduces the conductivity of the copper by 30 per cent. If traces of foreign matter are of such effect on the conductivity of copper, then it may well be possible that some of our present copper could be still further refined to advantage. It is fairly well known that the present methods of refinement yield copper whose conductivity is nearly 2 per cent higher than the best obtained by Matthiessen in 1861, when he gave us our value for "pure copper."

If electric apparatus were made with 2 per cent poorer copper than at present, the additional loss per ton of copper used would be about \$10 per year at 1 cent per kw. hr. (or \$100 at the price most of us pay for current) at 50 per cent load factor. As there are about one-quarter million tons of copper used annually in the electrical industry, this 2 per cent difference in the copper resistance constitutes the considerable perpetually-acting conservation of power resources of two and one-half million dollars a year. It seems highly improbable that this refinement of copper has reached the "ne plus ultra" stage, even from an economic standpoint.

In the case of iron, where again high electrical conductivity is frequently of greatest importance, it has been shown that less than 1 per cent of several other elements, such as carbon, silicon, arsenic, etc., reduce the conductivity to about half the value for pure iron. High-resistance iron alloys, being cheap, are commonly used for their high resistance. All electric street cars carry a hundred pounds or more of such iron resistance.

Then there are the changes in conductivity produced by annealing or softening hard metals.

An exceedingly interesting case of conductivity is that which takes place in an arc. Dr. Whitney points out that a theory of the arc in air which postulates only a passage of negative electrons which causes some wasting away of the cathode, would apparently cover the known phenomena of the arc. But



we are not sure that the phenomena of an arc in a confined and partially evacuated space can be considered as similar to those in an arc at atmospheric pressure. It is possible that in a confined and partially evacuated space the positive ions migrate from anode to cathode, where they are neutralized by negative electrons. Dr. Whitney thinks that the positive ion, at least in gaseous conduction is soon going to become as firmly fixed in our vocabulary as it is in the case of electrolytic conduction.

With respect to the conductivity of solutions in water a noteworthy fact is that at ordinary temperatures it never reaches anything like the magnitude of the arc or metallic conduction. While we may by suitable selection of concentrations produce any desired low conductance value, we cannot exceed about one-ten-thousandth of that of metals.

We find also in general a fairly uniform value for the effect of temperature on the electrolytic conductivity, but this is quite different in amount and sign from that of the metals. It usually lies between 5 and 6 times as great for aqueous solutions at ordinary temperatures. In the case of aqueous solutions the evidence of the migration of ponderable material, both in negative and positive direction, is too convincing to be questioned, and the commonly occurring but not necessarily visible decomposition at the terminals of this type of conductor differentiates it from the metallic type.

In conclusion Dr. Whitney expressed the hope that when the theories of conduction are well advanced we will also have obtained some conception of the rationale of temporary and permanent magnetism.

#### Symposium on Electric Conductance.

The presidential address of Dr. Whitney was followed by the symposium on conductance. It is proposed to arrange a symposium on some important subject of live interest for every annual meeting of the Society and the arrangements for this symposium will be in the hands of the president. At such symposium men actively at work on the subject under discussion are to be the principal speakers and a general discussion is to follow. President Whitney had chosen the general subject of "electric conductance" for this year's discussion and his selection proved excellent, the interest centering especially in the application of the electronic theory to gases and solids.

Dr. D. F. COMSTOCK, of the Massachusetts Institute of Technology, was the first speaker. He presented a concise general sketch of the modern theories of the intimate structure of matter in so far as they bear on the phenomena of conduction. Dr. Comstock distinguished three fundamental realities which go to make up the visible structure of matter. These are atoms, electrons, and energy (in general, electromagnetic energy, gravitation only being neglected which is a small force).

Of atoms there are about 100 different kinds, and we have learned in recent years to consider the atom as a far more complicated structure than heretofore.

Electrons are very much smaller than atoms and to emphasize this point Dr. Comstock used the comparison of a pin head with an office building. Electrons are only of the negative kind.

Radiant energy has momentum when it moves. It exercises a pressure on surfaces which reflect or absorb. It may be said in general that energy behaves very much like matter.

Atoms, electrons, and energy are the only three entities needed for building up our model of the visible world.

Positive electricity does not occur in form of electrons. But in every atom is incorporated a certain (very large) amount of positive electricity and the atom is neutral if it is also provided with just such a number of negative electrons as to balance the positive electricity.

Charging an atom positively means to take away a negative electron. Charging an atom negatively means to add a negative electron.

The relative number of electrons which can be added to or

taken away from an atom is very small. This number determines the chemical valency. The properties of elements can be explained by this affinity of the atoms for the electrons.

Electrification of a body by conduction is simply the separation of electrons. It is simply a separation within the two bodies in contact. Nothing is added.

Electrons in metals move like ions in electrolytes with this important difference. The positively charged atoms in the metal remain in the same position. What moves is only the negative electrons and they move in a direction opposite to that arbitrarily assumed for the electric current.

Dr. Comstock emphasized that the speed of electrons in metals is of the same order of magnitude as that of ions in electrolytes. This speed is in the order of centimeters per second. It is important that the electrons do not move with anything like the velocity of light as is sometimes assumed. What moves with such enormous velocity is the impulse.

In general the conductivity of every substance depends firstly on the number of electrons or ions; secondly, on their valency (that is the number of free electrons, being one or two, etc.) and thirdly on the frictional resistance which they encounter when they move along. There is not the propagation of a wave motion. There is not the flow of ether. All electric currents are convection currents. All conductance is the bodily movement of the electrons.

The next speaker was Dr. E. WEINTRAUB of the General Electric Company, of Lynn, Mass., who criticised severely the arbitrary and injudicious application of the electron theory to new fields for which it has not yet been proven applicable. He also offered some interesting positive generalizations. One of these is the classification into good and poor conductors which although not exactly sharp was shown to be much more far reaching than is generally supposed.

Dr. Weintraub considered first the conductivity of elements. Metals are good conductors and their conductivity becomes infinite at zero absolute temperature. He asked what explanation the electron theory could offer for this fact. It is true that the temperature coefficient of resistivity of metals is nearly constant and nearly equal to that of the extension of gases but the conditions are very different when we pass over to poor conductors. Dr. Weintraub cited boron as a striking example. The resistivity diminishes here very rapidly with an increase of temperature. While the good conductors generally obey a law of variation of resistivity with temperature such as  $1/R_0 \frac{dR}{dt}$  it is entirely different with poor conductors like boron which obey a law like  $\lg R = a + bt$  where  $R$  is the resistivity and  $t$  is the temperature. Dr. Weintraub asked how the electron theory accounted for this difference in the laws for good and poor conductors.

He then passed over to the discussion of solid solutions. It is a general rule that if another element is added to a good conductor the conductivity decreases, for instance, when a little copper is added to pure silver or where a little silver is added to pure copper. On the other hand if some addition is made to a poor conductor like boron the conductivity increases; this is, for instance, the case if a little iron is added to boron. This is a characteristic feature of all poor conductors.

Dr. Weintraub then took up the conductivity of compounds. As to the agreement between theory and facts with respect to the parallelism between thermal and electric conductivity he said this agreement was much emphasized by the advocates of the electron theory, but was probably overemphasized, since serious deviations do exist, especially at low and at high temperatures. Further the law does not hold at all for poor conductors.

Again with respect to the relation between conductivity and density trouble is experienced with poor conductors. In general it would seem that the relations between conductivity and other properties hold only for good conductors.

Possibly the step to the infinitely small electron has been too big a step. It is perhaps more important for the present to



investigate how metals crystallize, since we know this to have an effect on conductivity. We do not know yet enough of the internal microstructure of solids and solid salts.

Prof. R. A. MILLIKAN, of the University of Chicago, said, first, in reply to Dr. Weintraub, that the electron theory demands lack of parallelism between the behavior of good and poor conductors.

He then gave a fascinating sketch of his further researches on the isolation of electrons in gases by means of his oil drop method, described in our Vol. VIII, p. 638 (November, 1910). Currents are nothing but electric charges in motion and by means of his method he is now able to measure the elementary electric charge,  $e$ , the charge of an electron, with highest accuracy.

The results of his further more recent researches may be summed up in two statements.

First, Professor Millikan has been able to demonstrate that the process of ionization in gases produced by all kinds of ionizing agents which he employed consists in the detachment of one single electron. Hence the phenomenon of valency does not manifest itself so far in gases.

Second, the very careful extension of his fundamental researches on catching electrons with oil drops has led to a result which may be expressed in either of the following ways: His results may be considered either as a complete proof of the absolute identity of gaseous ions and electrolytic ions, or, if this is assumed as having been previously established, then it is a complete quantitative proof of the correctness of the kinetic theory of matter. The research from which this result was obtained had to do with Einstein's theory of the Brownian movements.

Dr. O. W. RICHARDSON, of Princeton University, was the next speaker. He thought that Dr. Weintraub required too much from the electronic theory; electronic conduction and electrolytic conduction cannot be compressed into a single formula. If the electronic theory explains some simple relations only it is valuable.

A case in point is the old law by Wiedemann and Franz that for good conductors the ratio of electric to the thermal conductivity is independent of the nature of the metal. Lorenz found that the temperature coefficient of this ratio is the same for all substances and very close to the temperature coefficient of the expansion of the gases. Now Drude has shown in a very simple way how these laws follow from the electronic theory. The agreement is pretty good and certainly remarkable.

One of the strongest arguments in favor of the electronic theory of the conduction in metals, in Dr. Richardson's opinion, is the fact that electrons are shot off when a metal is heated. There is a close analogy between this emission of electrons and evaporation. One may say that electricity evaporates in form of negative electrons, and may speak of the vapor pressure of negative electricity.

The first speaker of the afternoon session was Dr. M. W. FRANKLIN, of the General Electric Company, Schenectady, N. Y., who gave a concise outline of the experimental researches with vacuum tubes carried out by J. J. Thomson, Wilson, Millikan and others, which have resulted in the measurement of the electric charge and of the ratio of the electric charge to mass of electrons in gases.

Dr. H. M. GOODWIN, of the Massachusetts Institute of Technology, then gave a review of the extended researches carried out by him and under his direction on the conductivity of fused salts. Faraday's law holds for fused salts as for aqueous solutions, but when we try to apply the model of migrating ions to fused salts we encounter the difficulty that the velocities of the ions cannot be directly measured, since in a homogeneous material like a fused salt the transference numbers cannot be determined as in solutions.

It is only in indirect ways that we can hope to get the values of the mobilities. The first way is by comparison of the con-

ductivity of a solution and its change with temperature with the viscosity of the same solution and its change with temperature. The second way is based on specific heats and latent heats of fusion; and the third way is based on the measurements of the e.m.f. of cells with fused salts. These three different methods were sketched by Dr. Goodwin.

The indications are that fused salts are highly ionized and that even solid salts below the melting point are highly ionized so that the increased conductivity of a salt in the state of fusion is due rather to the change in viscosity and therefore to greater mobility of the ions than to a larger number of ions.

Dr. P. G. NUTTING, of the Bureau of Standards, Washington, D. C., then discussed the characteristic curves of conduction through gases in which the current is plotted as function of the impressed e.m.f., and illustrated various applications of these curves.

Dr. C. J. DAVISSON, of Princeton University, gave a long account of experimental researches on electric charges given off from heated salts. With alkaline salts and with alkaline earth salts the carriers of the electric charges seem to be the metals in the salt. Calcium seems to be present as an impurity in most of the salts. As far as evidence is available the current is not carried by gas molecules. It might be possible that part of the current is carried by metallic ions and part by gas ions, but no evidence for this has ever been found.

Dr. W. C. BRAY, of the Massachusetts Institute of Technology, discussed a general law proposed some years ago by Professor Kraus and himself, in order to give a single formula for inductance which covers all possible solvents and concentrations. This formula is

$$\frac{(C\gamma)^2}{C(1-\gamma)} = K + D(C\gamma)^m,$$

where  $C$  is the concentration,  $\gamma$  the degree of ionization calculated from the conductance ratio  $\Lambda/\Lambda_0$ , and  $K$ ,  $D$ ,  $m$  are constants. A more careful study, which is still in progress, has furnished striking confirmation of this law.

While the whole formula has been tested only in a few cases so far, the two terms on the right hand have been tested separately with good success, each term representing a special case.

The evidence that the law of mass action is obeyed in dilute solution is based on the experimental results of Franklin and Kraus in liquid ammonia and of Dutoit and his co-workers in propyl, butyl and amylalcohols and in acetone, sulphur dioxide, pyridine, etc. There is a rough parallelism between the values of  $K$  for a typical salt (as NaI) and the dielectric constants of the pure solvents. The deviations from the law of mass action are in general appreciable when the ion concentration is greater than 0.0005 normal.

The values of  $m$  usually lie between 0.4 and 0.6 in aqueous solution and between 0.9 and 1.2 in liquid ammonia and are still larger in solvents of lower dielectric constants. Whenever  $m$  is greater than 1, the values of the equivalent conductance pass through a minimum as the concentration increases and then increase with increasing concentration.  $D$  is the controlling factor in determining  $\gamma$  at high ion concentration, and usually lies between 0.1 and 5.0 for the different solvents. The above law ceases to hold in the neighborhood of normal concentration, and  $\Lambda$  then decreases with increasing concentration. There is evidence that this decrease is connected with the rapidly increasing viscosity of these concentrated solutions.

The next speaker was Prof. CHARLES A. KRAUS who drew attention to an interesting link between metallic and electrolytic conduction proving that, after all, metallic conduction cannot be radically different from electrolytic conduction.

This most interesting link is furnished by the consideration of solutions of metallic sodium in liquid anhydrous ammonia. In general the solution behaves like an electrolyte, but when it becomes very concentrated it behaves like a metal and it also has the appearance of a metal.

The last formal speaker of the symposium was Dr. S. J. LLOYD, who pointed out that, with very few exceptions, pure ordinary salts, oxides, bases, are very poor conductors. But when the temperature is raised the conductivity increases.

It is difficult to apply the electrolytic dissociation theory to this field. The present opinion concerning the mechanism of conduction in solid and fused salts is that not only are pure fused salts highly disassociated, but solid substances are also highly dissociated so that the degree of dissociation in the fused state is not so very different from that in the solid stage. The much greater conductivity in the fused state is then due to the viscosity change which causes greater ionic mobility.

The general discussion which followed was opened by Dr. Whitney.

Dr. Weintraub agreed that some excellent work has been done on electric conduction in gases. Undoubtedly in gases the electrons are the carriers of the electricity. It can be understood that attempts are being made to transfer the electron theory to wider fields. But it should not be forced artificially on solid conductors. Dr. Weintraub considered the agreement between theory and practice with respect to the parallelism between thermal and electric conductivity as more or less accidental.

Dr. Richardson replied explaining why he considered this special agreement as really significant and as a strong support of the electronic theory.

Dr. Comstock pointed out the extraordinary difficulties which are met with in the development of the theory. One has to proceed step by step and it is of greatest importance to get some positive results.

Dr. Millikan agreed with this and told the story how his little nephew came home from school thoroughly disgusted with his teacher because "she has said all week three and four is seven, and now I have learned the darned thing, she says five and two is seven."

#### Demonstration of New Apparatus. Determining Carbon in Iron and Steel.

Mr. F. W. Robinson, of the Hanovia Chemical Manufacturing Company of Newark, N. J., then demonstrated some new apparatus placed on the market in this country by Mr. Chas. Engelhard, of New York City.

The first was an electric furnace for the quick determination of carbon in iron and steel. The method is to burn the carbon

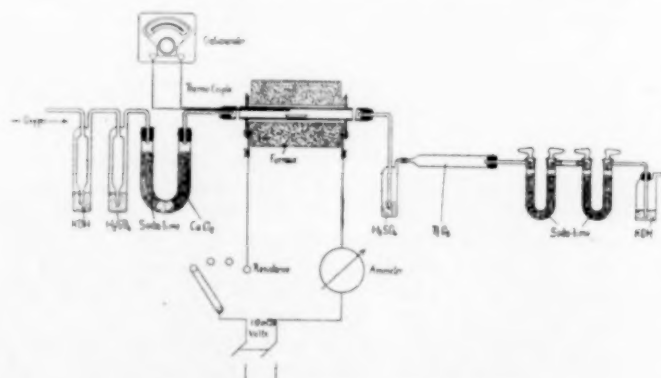


FIG. 3.—DETERMINING CARBON IN STEEL.

in a stream of oxygen and absorb the carbon dioxide thus produced. The method was not successful until the use of the electric resistance furnace provided a sufficiently uniform temperature for a satisfactory combustion. Mr. G. Mars, of the Bohler Steel Works, in Germany, has shown that with a suitable furnace the method is not only simple and accurate but on account of its rapidity is eminently suitable for use with the open-hearth process, particularly when with varying charges the Eggertz tests are unreliable.

The arrangement is shown in Fig. 3, permitting any number of estimations to be made successively almost without interruptions, so one man working two sets of apparatus can make 20 to 24 determinations a day.

The combustion is carried out as follows: The furnace is first heated up to a temperature of 700°-1000° C. (for cast iron 700°, for ordinary steel 900° and for some special steels 1000°) during which a slow stream of oxygen is passed through the apparatus. The soda lime tubes are then weighed (all weighings are made with the soda lime tube full of oxygen) and connected to the apparatus again. One to two grams of the metal in the form of turnings as there weighed into a porcelain boat and the boat slid into position in the furnace. This is done from the front end so that the thermo-couple and oxygen inlet tube need never be disturbed. The boat should be slid in so far that the back end is flush with the junction of the thermo-couple and during this operation the stream of oxygen should not be interrupted. The rubber stopper is immediately replaced in the combustion tube and the taps of the soda-lime tubes opened.

The temperature of the furnace is then gradually raised, with steel during 15 mins., with cast iron during 20 mins., to a maximum of 1150°-1200° C. The beginning of the reaction can be noticed by a visible reduction in the rate of the gas through the H<sub>2</sub> SO<sub>4</sub> washbottle. Provided the turnings used are not too coarse, the heating current may be cut off as soon as the maximum temperature is reached, otherwise this temperature should be maintained for 5 to 10 minutes before cooling down. After completion of the combustion the stream of oxygen is continued for 5 mins. to drive all the CO<sub>2</sub> into the absorption tubes and these are then disconnected and weighed.

To obtain accurate results with difficult combustible materials such as ferro-chromium and ferro-manganese the turnings must be mixed with an oxygen yielding substance such as bismuth oxide and the combustion is then conducted as before.

#### Pyrometry.

The second demonstration of Mr. Robinson referred to "some recent developments in the field of temperature measurement."

Mr. Robinson first showed a copper-constantan thermo-element, of which not less than 1100 are used on German locomotives for measuring the temperature of superheated steam. The copper-constantan element is built into the slide-valve chamber and the indicating galvanometer is fixed onto the boiler casing in the driver's cab. Comparisons with a mercury thermometer showed that the latter was lagging several minutes behind the thermo-element, with serious consequences.

In the construction of resistance thermometers an important advance has been made by Dr. E. Haagn, of the firm of Heraeus, by completely embedding the platinum resistance wire in fused quartz, and at the same time adjusting the resistance to a standard value within 0.04 per cent. This value is usually 50 ohms, but can within limits be increased or decreased at will. The significance of this is obvious, for, embedded in the quartz glass, the resistance cannot change through mechanical or chemical influences and the resistance elements are interchangeable without alteration to the galvanometer scale or any part of the installation.

The process of embedding in quartz has been shown by the Reichsanstalt to alter the physical constants  $a$  and  $b$  in the expression for the relation of resistance to temperature

$$R_t = R_0 (1 + at + bt^2)$$

This simply means that the temperature scale is slightly different from that for a wire lying free in the air, but the temperature scale for these thermometers has been carefully determined by the Reichsanstalt.



These quartz-glass resistance thermometers are also constructed for a number of special uses, e. g., the small volume and mass of the resistance element allows of the exact following of small and rapid temperature changes in physico-chemical investigations. For calorimetric measurements Heraeus has introduced a specially long resistance element (up to 25 cm) combining high resistance and consequent extra sensitiveness with the real temperature mean throughout the length of the calorimeter while for melting point and boiling point determinations an element of only 2 cm length and 25 ohms resistance is used.

For medical and physiological use a special mounting in gilt capsules of a quartz thermometer bent double in the middle to minimize space has been introduced by Siemens & Halske. It is usually advisable to connect it with a recording galvanometer and one sees at once the great advantage of this method over the usual  $\frac{1}{2}$  daily measurements with a mercury thermometer. These instruments can be introduced and retained for quite long periods even in the stomach or rectum without undue inconvenience to the patient and no attention is required, as they can be fitted with a signalling device for the critical temperature.

#### Quartz Mercury-Vapor Lamp.

The third demonstration by Mr. Robinson was that of the quartz mercury-vapor lamp for scientific and medicinal uses. Perhaps its most important quality is its richness in ultra-violet rays, for which the fused quartz, unlike glass, is transparent down to the wave length 185  $\mu$ . This lamp is therefore a very rich source of actinic rays for photochemical and botanical research. For medicinal uses two types of the lamp are on the market. The first is the Kromager lamp for the treatment of local surface and allied disorders. The second is the Bach lamp and is known under the name of the "miniature Alpine sun."

#### Saturday Meeting.

The Saturday morning session was held in Pierce Hall of Harvard University. During the session Dr. THEO. W. RICHARDS welcomed the Society in a felicitous little speech to Harvard and gave an outline of the new buildings of chemistry now under erection at Harvard. He pointed out the advantages which the erection of various buildings has over the standard European system of centralization in a single building. Of course, there are also some disadvantages.

#### Vacuum Furnace Metallurgy.

The first paper of the Saturday session was presented by Dr. COLIN G. FINK, of the General Electric Company, of Harrison, N. J. He described experiments carried out with the idea of ascertaining whether ores, particularly complex or "rebellious" ores, such as smaltite, containing arsenic, sulphur, phosphorus or similar elements, could be more readily and more economically reduced in a vacuum.

Experiments were made with the treatment of smaltite ore from Canada, in a vacuum electric furnace. Simple heating of the ore without any additions was first tried, but without great success. Up to temperatures of about 1500 deg. C., but 40 per cent of the arsenic present in the ore is expelled. It is only after exceeding the melting point of cobalt that a further reduction of the arsenic is brought about. If silver is present in the ore, it distils out at about 1300 deg. and can be collected in a chamber fitted into the cooler portions of the furnace.

Since it proved difficult to reduce the ore by intense heating, Dr. Fink tried the effect of additions. Of all those he tried the most effective was calcium carbide or a mixture of calcium carbonate and carbon.

With a mixture of 20 parts  $\text{CaO}$ , 6.4  $\text{CaC}_2$  and 30 parts ore, when the charge was heated at 1500 deg. C. for  $1\frac{1}{2}$  hours, the percentage of arsenic in the product was 2.1. In this case the calcium oxide and carbide react with each other:  $2\text{CaO}$

+  $\text{CaC}_2 = 3\text{Ca} + 2\text{CO}$  and the metallic calcium combines with the arsenic:  $\text{CoAs}_2 + 3\text{Ca} = \text{Ca}_3\text{As}_2 + \text{Co}$ . Calcium arsenide separates from the reduced cobalt as slag and part of the arsenic is volatilized.

The second part of Dr. Fink's paper describes experiments made with Nipissing ore. One lot analyzed 9.65 per cent cobalt, 4.65 nickel, 28.65 arsenic, 18.06 silver, 39 gangue.

The behavior of this ore was very similar to that of the smaltite ore. When heated alone a splendid separation was obtained into crude silver (83 per cent Ag), metal speiss, and slag. Upon cooling, the three layers can be very easily separated mechanically. (U. S. patent 996,479.)

The dividing line between silver and speiss is exceedingly sharp in the vacuum furnace product. A number of comparative runs were made in a carbon resistance furnace of the Moissan type, the gas pressure in the furnace being one atmosphere. Although a separation of the crude silver, speiss, and slag was obtained, it was very incomplete and the volume of arsenic fumes evolved was most annoying.

In the vacuum furnace it was found convenient to make the runs in two stages. During the first stage the temperature was maintained at about 1250 deg. to 1350 deg. for two hours. At the end of this time, instead of cooling down or tapping off the three components, the temperature was still further increased to 1550 deg. to 1600 deg. and the charge kept there for about three hours. At this temperature the silver distilled out, leaving the speiss and slag behind.

The composition of the charge at the end of the first stage was, crude silver (lowest layer) 27 per cent; speiss, 47 per cent; slag, 20 per cent, and arsenic (distillate) 8.5 per cent. The addition of 5 to 10 per cent of coke facilitates this separation of silver, speiss, and slag. Its action is partly chemical, as a reducing agent, and partly physical, in so far as it keeps the charge porous, allowing the gases to escape readily. The crude silver of three runs assayed 81.34 per cent, 82.21 per cent, and 83.7 per cent silver. There was no silver found in the slag, and none in the distillate at the end of the first stage. At the end of the second stage (1600 deg.) all of the silver was in the distillate and none in either speiss or slag.

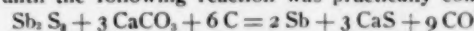
The third part of Dr. Fink's paper deals with the production of antimony from stibnite. A vacuum-furnace process is suggested by the low vacuum boiling temperature of antimony. Under atmospheric pressure the metal melts at 632 deg. C. (Pelabon) and does not boil until a temperature of 1500 deg. to 1700 deg. is reached. The boiling-point in the vacuum, however, is not more than 100 deg. above the melting-point.

Dr. Fink's experiments show that either iron or, as before a calcium oxide and carbon mixture, may be employed as reducing agent. In the former case, with a temperature of 600 to 700 deg. C., the reaction



proceeds almost quantitatively in presence of an excess of iron. If this reaction is first allowed to take place, and the temperature then raised to 900 deg. to 1250 deg., the antimony will readily be distilled away from the sulphide of iron. If calcium oxide and carbon are used, the best results are obtained by using for every 11.3 parts of stibnite (62 per cent Sb), 12 parts limestone,  $2\frac{1}{2}$  parts coke, and 6 parts fluorspar.

All ingredients of the charge were finely ground (40 mesh) and thoroughly mixed. The heating was performed in two stages; the temperature was gradually raised to 600 deg. to 700 deg., and maintained at that point for one to one and a half hours, until the following reaction was practically complete:



Thereupon the current was slowly increased until a temperature of about 1300 deg. was obtained, and after about one hour's heating at this point the charge was allowed to cool in vacuum. The addition of  $\text{CaF}_2$  to the charge seems to facilitate the separation (by distillation) of the Sb from the slag in the second stage of the heating. At all events, better results were obtained with than without the addition of this flux.



Dr. Fink concludes that this  $C + CaCO_3$  or calcium carbide-vacuum method is cheap, and when the conditions are properly chosen the output is over 95 per cent. The product is practically equal in quality to that obtained by the "iron method."

As another application of vacuum-furnace metallurgy Dr. Fink mentions a gold-silver separation process of W. C. Arsem which consists in heating the alloy of these two metals in a vacuum furnace to a temperature of about 1300 deg., to distill off the silver. If platinum is present in the alloy, the temperature is raised, after the silver distillation is complete, to about 1500 deg., and the gold distilled over.

Dr. Fink's paper was discussed by Messrs. Richards, Hering, and Johnson.

#### Standard of Radio-Activity.

Mr. MERLE RANDALL presented a paper giving an extended account of an investigation carried out at the University of Missouri on "the Boltwood standard of radio-activity."

One of the experimental results is that in general no constant relation exists between the Boltwood emanation standard and the C. G. S. electrostatic standard as ordinarily used.

The maximum ionization current produced in the ordinary electroscopes by the radium emanation and its products from an old mineral containing one gram uranium was calculated as  $6.18 \times 10^{-10}$  amp. or 1.854 C. G. S. units.

For small electroscopes of the same design, the observed ionization current is nearly proportional to the volume of the ionization chamber.

The "ionization efficiency," i.e., the ratio of the observed to the maximum ionization current, was found to vary between 39 and 79 per cent for the electroscopes studied.

Several forms of apparatus for separating the radium emanation from its solutions were studied, and the approximate efficiency of each form determined.

All the forms of apparatus for separating the emanation were successfully improved, so as to avoid all loss of emanation in the transfer of the gas from the collecting bulb to the electro-scope.

In standardizing the electroscopes it is necessary to so arrange the standardizing experiments that nearly the same quantity of radium emanation is boiled off as in the later determinations.

A new form of electroscope is described by the author and its merits proven.

An improved method of mounting the plate glass inserts in the brass frames of several types of electroscopes is described, also a new form of cradle mounting for the reading microscope of electroscopes.

It is shown that in the case of some of the electroscopes the potential is proportional to the scale divisions over the range of the reading microscope. In other electroscopes this proportionality did not hold.

Small "flashlight" dry batteries were used and found satisfactory as a source of potential for calibrating and charging electroscopes.

A peculiar "crawl" effect was observed with electroscopes having sulphur insulation. The effect of this effect upon the rate of fall of the leaf is pointed out.

An anomaly in the air-leak was observed in some of the electroscopes used. The rate of leak decreased with the time-interval of charge of the leaf.

#### Dry Cells.

Prof. C. F. BURGESS then presented a preliminary report of the Committee on Dry Cell Tests (consisting of Messrs. C. F. Burgess, J. W. Brown, F. H. Loveridge, and C. H. Thorp) and also read a paper by Mr. CARL HAMBUECHEN on the "performances of dry cells."

The preliminary committee report gave an account of standard methods which are recommended tentatively for the testing of dry cells. In view of the importance of the subject and in view of the fact that a paper on the same subject (emanating

from the British National Physical Laboratory) has just been presented before the Faraday Society in London, all the dry cell papers are being reserved for our next issue when the subject will be covered in full.

#### Diffusion and E. M. F. Produced by Centrifugal Action.

The President-Elect, Dr. W. LASH MILLER, of the University of Toronto, presented a paper on "the influence of diffusion on electromotive force produced in solutions by centrifugal action."

In Tolman's measurements of the electromotive force produced in solutions by centrifugal action (Proc. Amer. Acad. Arts & Sci., vol. 46, p. 109, 1910), the equations for the electromotive force are deduced without allowing for any possible differences in concentration at the two ends of the tube produced by the whirling. As in some of his experiments these differences would become considerable if the rotation were sufficiently prolonged, it seemed possible that even in a few minutes the "concentration cell" effect might become measurable, and that it might perhaps account for the "residual electromotive force" observed by him.

Dr. Miller gives in the present paper the complete mathematical theory of the rate at which diffusion would take place under the influence of centrifugal force. Its application to Tolman's work shows, however, that the polarization produced by concentration changes in short periods of centrifuging is very slight and that the effect is much too small to account for the "residual" voltage observed by Tolman.

#### Phase Potentials.

A paper by Dr. REINHARD BEUTNER, of the Rockefeller Institute of Medical Research, deals with "potential differences at the junction of immiscible phases."

In the first part the emf's of cells formed of solid salts are discussed. For instance, a cell, made up of two solid silver salts, as follows:



has an emf exactly equal to zero. The reason is that no change is possible in this system.

It is quite different if a sodium salt is added; for instance,  $Ag - \text{solid } AgCl - \text{solid } NaCl - \text{solid } Na_2SO_4 - \text{solid } Ag_2SO_4 - Ag$

This cell shows an emf because in it the reaction



is possible. The emf will have such a direction that the current produced by it causes formations of those two salts which are in equilibrium or will not react with each other; these are  $AgCl$  and  $Na_2SO_4$ . That is, the silver electrode in contact with  $Ag_2SO_4$  must be the positive pole and this is really the case. The emf calculated from thermochemical data is 0.535 volt, in good agreement with the experimental measurements.

Now, cells made up of saturated solutions or molten salts behave in a very different way. Hence the potential difference at the junction of two immiscible phases (or the "phase potential") is very different from the potential difference between aqueous solutions or between fused salts. The "phase potential" behaves very much more like a potential difference at metals. An important analogy between the two is that the potential difference between a metal and a solution of one of its salts varies with the concentration of the solution according to a logarithmic law, and that exactly the same rule holds good for phase potentials.

Phase potentials are of especial importance for electric phenomena in animals and plants. Organic tissues are built up from cells surrounded by membranes. These membranes separate aqueous solutions of various substances (among them salts) from each other. Although the chemical composition is unknown, any membrane may be assumed to have a small electrolytic conductivity (possibly of the order of magnitude of a solid salt). Then phase potentials will exist on both sides of the membrane.

Dr. Beutner gave an account of phase potential measurements on fruit skins and leaves and stated some general results there-

by obtained. Finally discussing the relation of this subject to Nernst's excitation law, he concluded that in the experiments with fruit skins and leaves, just mentioned, they have roughly imitated one of the processes which take place many thousand times in our nerves and muscles, when we move.

Dr. Beutners paper was discussed by Dr. Whitney and Dr. Bray.

#### Lead Plating.

A paper by Prof. FRANK C. MATHERS and O. RALPH OVERMAN, of the University of Indiana, on "the effect of addition substances in lead plating baths," was read, in the absence of the authors, by Dr. Schluederberg.

This paper gives the results of experiments to find the best addition substances for use in lead plating and refining baths.

The following classes of compounds were tried: Inorganic, essential oils, resins and gums, sugars and starches, alkaloids and their derivatives, glucosides, proteids and nitrogenous animal substances, ferments and enzymes, phenols and miscellaneous substances.

Some compound in all organic classes showed marked beneficial action. Most of the compounds were without marked beneficial action.

All effective addition agents contain the hydroxyl group. This is too general a relationship to be of any value.

The addition substances, arranged in the order of their beneficial action, are: Clove oil or eugenol, peptone, phloridzin and gum guaiac.

Clove oil is recommended for use in lead perchlorate plating and refining baths. About one-third of a pound is required per ton of lead.

Phloridzin is, perhaps, a slightly more satisfactory addition substance, but its cost is prohibitive for anything but experimental work.

Other satisfactory addition substances may be discovered among the oils and gums. These fields have not been completely covered.

A communicated Discussion by Mr. Victor Engelhardt referred to two patents of Siemens & Halske and Nussbaum (German patent 223,152 and an older United States patent 832,024) relating to processes covered in the paper.

Dr. Bancroft criticized some of the authors' conclusions with respect to their applications to the theory of electrolytic deposition. "An effective addition agent forms a dispersed phase, solid or liquid, which is carried to the cathode by the current and is absorbed by the precipitating metal." This definition excludes sodium chloride from the list of addition agents. But there is no more reason to call sodium chloride an addition agent for copper than to call potassium cyanide an addition agent for silver. These substances do not form dispersed phases and are not carried as such to the cathode by the current. They act by cutting down the ion concentration and the hydrolysis, and by changing the corroding action of the solution on the metal or the salts of the metal. It is merely a source of confusion when two fundamentally different phenomena are grouped together.

#### Electric Endosmose.

Prof. WILDER D. BANCROFT, of Cornell University, presented a paper on "electrical endosmose." Perrin has made the generalization that all porous diaphragms become charged positively in a solution which is strongly acid and become charged negatively if the solution is sufficiently strongly alkaline. This is the same as saying that electrical endosmose will carry the acid solution through the diaphragm from cathode to anode and will carry the alkaline solution through the diaphragm from anode to cathode. Without discussing whether this generalization is or is not absolutely accurate for all diaphragms, Professor Bancroft showed in his paper how certain apparent exceptions may be accounted for.

It was emphasized that the relative adsorption of cations and anions by a diaphragm determines the sign of the charge on a

diaphragm, being positive if the cation is adsorbed to a greater extent than the anion and negative if the reverse is the case.

Various experimental facts with respect to both the movement of solutions through diaphragms and the analogous movement of colloids in solutions under the influence of the current were described and discussed in their relation to the theory of electroplating.

For instance, Müller and Bahntje found that, in acidified copper sulphate solutions, starch and gum arabic did not move to the cathode and did not cut down the size of the copper crystals when the solution was slightly acid; but did both these things when the solution was made more acid. The movement of the colloid to the anode in a slightly acid solution in a porous-cup experiment described is exactly analogous. Of course, the reversal will come at different degrees of acidity with different colloids. In fact, Müller and Bahntje found that gelatine moved to the cathode in solutions in which starch moved to the anode. The effectiveness of gelatine in cutting down the size of lead crystals in the Betts process is due largely to the fact that the solution is markedly acid.

Aluminium sulphate is often added to zinc baths to improve the quality of the zinc deposit. The explanation for this has been given by Schlötter. "Since aluminium sulphate is dissociated hydrolytically, in aqueous solution, into sulphuric acid and colloidal aluminium hydroxide, the action of aluminium sulphate is clearly that of a colloid. We get a similar result when copper is deposited electrolytically in presence of aluminium sulphate."

The electrolytic precipitation of black, perverulent copper from a dilute copper sulphate solution is also cleared up. This is shown to be due to hydrolysis, with a formation of too much colloidal cupric oxide (too much relatively to copper as ion).

#### Rotating Cathode.

A paper of Dr. C. W. BENNETT, of Cornell University, described details of construction of a rotating cathode, built at the suggestion of Professor Bancroft, in order to obtain samples of metals and alloys by precipitation with high current density for the purpose of studying their physical properties.

The revolving cathode described will operate at speeds up to 6000 r.p.m. It will carry 300 amp, giving a current density of about 3500 amp per square foot when 4 in. of the cathode is receiving a deposit (385 amp per square decimeter on 10 cm). The metal can be removed in nice shape for testing physical properties without subjecting to strain of bending or heating.

#### Tensile Strength of Electrolytic Copper.

A second paper by Mr. C. W. BENNETT related to "the tensile strength of electrolytic copper on a rotating cathode."

After reference to the commercial processes of Elmore and Cowper-Cowles for the electrolytic deposition of copper on rapidly rotating cathodes, the author described his own experimental arrangements.

A few fundamental relations were first emphasized. In general, if a solution is stirred during crystallization the crystals resulting are smaller than those from the same solution without stirring. It is also known that the tensile strength of steel, copper, etc., is increased by rolling. Rolling does nothing more than break down crystal aggregates, giving a more finely crystalline mass. Hence, with the precipitated copper an increase of tensile strength was expected with a decrease of crystal size as the rotation was increased. When this was tried the results showed that the theory was correct.

A solution containing 20 per cent  $\text{CuSO}_4 \cdot 5\text{H}_2\text{O}$  and 12 per cent  $\text{H}_2\text{SO}_4$  was used. The temperature at starting was 35° C. This was desirable, for trial showed that this was the temperature maintained throughout a run at the current density used, i.e., 500 amp per square foot (53 A. per square decimeter). The deposits were treated alike and every precaution was used to keep all conditions, save speed of rotation, constant.

The results are given in Fig. 4. There are two tensile strength curves given, one in vertical direction, the other in

direction of rotation. If the hypothesis was correct that the particles are drawn out in the direction of rotation and a fibrous interlacing mass is obtained, then the tensile strength would always be greatest in the direction of lamination. As

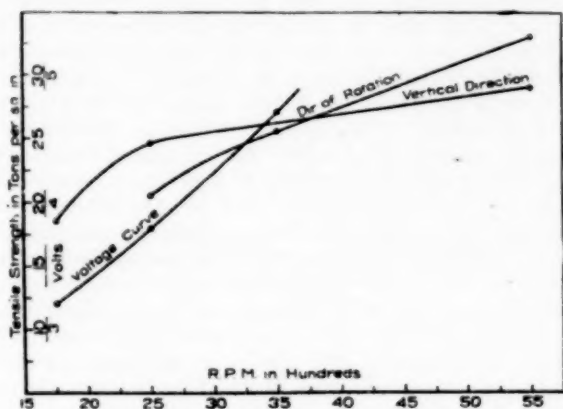


FIG. 6.—EFFECT OF TEMPERATURES.

the curves show that this is not the case, the above hypothesis is untenable.

The voltage curve in Fig. 4 shows that the voltage drop across the cell undergoes an astonishingly large increase with increase of speed of rotation.

The effect of variation of current density was next studied. Two sets of runs, one for a speed of the cathode 2500 r.p.m. and the other for 5500 revolutions, were made, the results being given in Fig. 5. The point brought out is that the maximum tensile strength is obtained at a higher current density when the rate of rotation and hence the rate of stirring is higher.

A few runs were made to show that the variation of the concentration of the electrolytic makes little difference in the difference in the tensile strength. But variation of temperature has a large effect.

If copper wire be drawn while cold through a die, the effect is a decrease in ductility and an increase in tensile strength. This is caused by the breaking down of the large crystals, giving smaller ones embedded more or less in amorphous material. The distance of shear through the crystal is relatively short and hence the elongation is short, or in other words the ductility is slight. The tensile strength goes up, for the material is worked more or less toward the amorphous end,

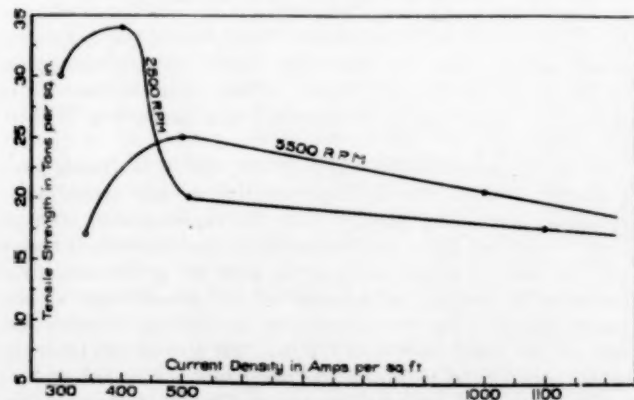


FIG. 5.—EFFECT OF CURRENT DENSITY ON TENSILE STRENGTH.

i.e., the crystals become smaller and under stress show a more even loading. If the hard drawn copper wire be annealed, the tensile strength goes down to about 30,000 lb. per square inch (21.0 kg. per square millimeter) as a limit, and the ductility

is increased. The crystals become larger, the distance of shear before they break is longer and hence the ductility is increased.

By depositing copper on a rotating cathode, from a solution at room temperature, it is possible to duplicate the cold worked copper, getting a hard compact sample with very slight difficulty and a high tensile strength. Now by raising the temperature of the solution and hence that of the uncrystallized copper deposited, it ought to be possible to anneal the metal while it is being precipitated. Or looked at from the other point of view, crystallization from a hotter solution should give larger crystals, other things being equal.

That this is indeed so is admirably shown by the test results of Fig. 6. The chief results of the investigation are summed up as follows:

"Copper has been deposited electrolytically at a current density of 4000 amp per square foot or about 430 amp per square decimeter.

"In the electrolytic precipitation of a metal the crystal size decreases as the cathode is rotated more rapidly, other things being equal.

"The crystal size decreases as the current density increases and increases as the temperature rises.

"The concentration of the electrolyte can be varied quite a little without changing the character of the deposit.

"If the precipitation is carried on at a high temperature an

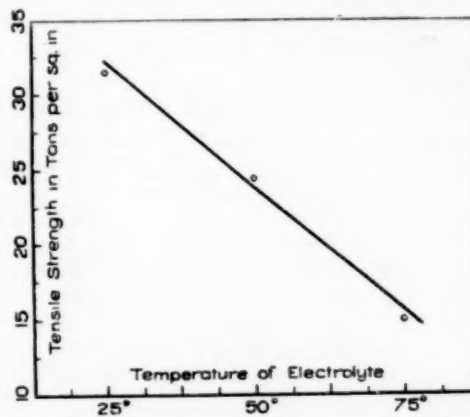


FIG. 4.—EFFECT OF SPEED ON TENSILE STRENGTH AND VOLTAGE.

effect similar to annealing is accomplished during the electrolysis.

"The tensile strength of metals varies inversely as the crystal size, and hence any factor tending to decrease the crystal size tends to increase the tensile strength.

"The effect of rapidly rotating the cathode and of increasing the current density is to increase the tensile strength, the crystal size being decreased.

"A good deposit of copper could apparently be obtained at an infinite current density if the stirring were efficient enough to prevent impoverishment.

"The current efficiency at a high current density with rapid rate of rotation is high, it being 99.6 per cent.

"'Hard drawn' copper can be deposited on a rotating cathode at almost any current density, if the temperature be kept down; and likewise annealed copper if the temperature be kept at about 75° C.

"Electrolytic copper has been obtained having a tensile strength of 68,000 lb. per square inch (47.6 kg. per square millimeter).

"A deposit as good as the best can be obtained with a current density of 2400 amp or more per square foot (264 A. per square decimeter) with the rate of stirring used.

"With the alloys, the trouble is most likely a question of colloidal material.

"Acid solutions, with readily soluble salts, and no possibility



for the formation of colloids should be sought for as electrolytes in alloy precipitation."

The two papers of Mr. Bennett were discussed by Dr. Hering (who suggested that as the surface velocity was the decisive element the speed could be reduced if the diameter of the cathode was made larger), by Mr. Hibbard and Dr. Bancroft.

#### Smee's Theory of Electrolytic Deposits.

In a paper by Prof. WILDER D. BANCROFT with this title it is pointed out that in Smee's Elements of Electrometallurgy, published in 1842, there are some observations on the relation between current density and size of crystals, which appear to have been entirely overlooked or forgotten. Smee saw the analogy between crystallization and electrolytic precipitation and he knew that high current density and low concentration cause a decrease in the size of the crystals while a higher temperature gives rise to coarser crystals.

#### Regeneration of Sulphated Storage Cells.

In a paper by Messrs C. W. BENNETT and D. S. COLE, of Cornell University, it is shown that badly sulphated cells can be economically regenerated by electrolysis in sodium sulphate solution. The cost need not be greater than 20 cents per cell. Allowing 5 cents per kilowatt-hour for power, the increase in the efficiency of the cell will pay for the regeneration in about 90 charges and discharges or in about three months' daily use.

The concentration of sodium sulphate recommended, which can be varied within wide limits, is 200 gr. of the crystallized salt ( $\text{Na}_2\text{SO}_4 \cdot 10\text{H}_2\text{O}$ ) per liter. The sodium sulphate should be chemically pure.

#### Volatility of Zinc Oxide.

A paper by Prof. O. L. KOWALKE, of the University of Wisconsin, deals with the question as to the volatility of zinc oxide which is of importance for electric zinc smelting.

The author's experiments show that zinc oxide can be completely volatilized at temperatures from 1370 to 1400 deg. C.

The loss of zinc oxide increases rapidly with temperature rising above 1300 deg. C., as shown in these tests. The loss seems, however, to be of a nature similar to the slow evaporation of water below the boiling point, but at temperatures above 1400 deg. C. it appears reasonable to say that the volatilization proceeds rapidly.

#### Electrolytic Reduction of Blue Powder.

A paper by Mr. WARREN F. BLEEKER, of the Standard Chemical Company, of Canonsburg, Pa., describes an electrolytic method for the reduction of blue powder. Blue powder is essentially metallic zinc in a very finely divided condition, each particle coated with a film of microscopic thinness, and this film is the direct cause of the powder remaining as such, even at a temperature far above the melting point of zinc. It is well known that in various electric zinc furnace processes the condensation of zinc in liquid form has caused difficulties, blue powder having been obtained chiefly instead. Mr. Bleeker's process solves the problem how to treat the blue powder in a simple way.

The experiments were carried out in an iron pot which served as cathode, while an Acheson graphite rod was used as anode. Zinc chloride (previously dehydrated) was introduced into the pot and melted and electrolysis started. Blue powder was then added to the bath at regular intervals and stirred into the bath. It is reduced and the spelter deposits at once and accumulates rapidly in the bottom of the pot. The power consumption was one-tenth kilowatt-hour per pound of spelter. The process is not patented.

The paper was discussed by Dr. Hering and Mr. Sang.

#### Sherardizing.

A paper by Dr. ARDEN R. JOHNSON and Mr. WILLIS R. WOOLRICH, of De Paul University, "on the nature of zinc cementizing or sherardizing" was presented by Prof. Burgess.

The authors discuss the fundamental factors in the sherardizing process and describe results of tests made with pure zinc dust. These experiments refer to the relation of duration of heating to thickness of deposit, to the evolution of hydrogen from zinc dust, to the effect of temperature upon the rate of deposition of zinc, to the effect of the state of division of the zinc, and to the effect of mixing inert powders to the zinc dust.

From the results of their experiments the authors have evolved the following theory of the process of sherardizing. In the light of the phase-rule we may regard the iron, zinc and vapor as forming a closed system, all parts of which are practically at the same temperature. Zinc, compared with iron and most other metals, has a relatively high vapor tension. Zinc alloys fairly readily with many of the common metals like iron, nickel and copper. When the process is ready to be started, the iron, for instance, is surrounded and in intimate contact with many particles of zinc. Under the influence of heat these particles, carrying their slight atmospheres of zinc vapor, form a superficial alloy with iron. This superficial alloy on the iron would very likely be a solid solution of zinc very rich in iron. Now we may look upon the iron with its insignificant vapor pressure as greatly lowering the very appreciable vapor pressure of the zinc which is forming a solid solution with it, and we should expect the zinc vapor to distil from the points of higher tension to the place of low vapor tension at the surface of the iron-zinc alloy. As the iron alloy grows richer and richer in zinc under the process of sublimation or distillation, its vapor tension will gradually approach the tension of the vapor of pure zinc particles, and hence the process gradually ceases.

The experimental facts presented show that the nature of the metal to be "sherardized," having reference to its alloying properties with zinc, has a great influence on the temperature at which "sherardizing" will start and its rapidity after starting. That the authors did not succeed after several trials in depositing zinc on a pure zinc rod buried in zinc-dust is also in accord with our theory. Also pieces of iron which had once received a coat of zinc of considerable thickness refused to "sherardize" at any such rate as fresh iron at temperatures below the melting point of zinc. However, if the coat of zinc already present is thin the deposition will start again, though more or less tardily.

New lines for experimentation are suggested by this theory which should at the same time test its validity. One should expect zinc cementizing to be greatly retarded if the finely divided zinc used were a solid solution with some metal of low vapor tension, as iron, nickel or copper. If the vapor tension of the metal to be deposited is lowered until about equal to that of the most saturated solution possible on the surface of the metal being "sherardized," the process should not take place, or only to a slight extent. Furthermore, any substance which would impair or change the initial alloying tendencies of the metals should also greatly influence the process. It is along these lines that the authors are now proceeding in their experimentation.

In the discussion which followed Dr. Jos. W. Richards gave a theoretical curve for the vapor tension of zinc at low temperatures, derived by analogy from the vapor tension of mercury. From this curve and the author's determinations it seems that the rate at which sherardizing goes on at different temperatures is roughly proportional to the square root of the vapor tension. But the process of sherardizing depends not only on the vapor tension of the zinc, but also on the tendency of the other metal to absorb the zinc vapor.

The paper was further discussed by Messrs. Arthur, Miller, Bancroft and Duschak.

#### Corrosion of Iron by Sulphuric Acid.

The last paper of the meeting deals with "the effect of various substances on the rate of corrosion of iron by sulphuric acid," the author being Dr. OLIVER P. WATTS, of the

University of Wisconsin. The author refers to the fact that arsenic precipitates itself upon iron from solution and yet protects the iron almost completely from powerful corrosive agents. He offers the hypothesis that the explanation lies in the high overvoltage of hydrogen on arsenic. To test this hypothesis he has carried out an extended experimental investigation. The results confirm the hypothesis in a general way. Other metals of high overvoltage have a protective influence, while all metals of low overvoltage which deposit on iron are accelerators of its corrosion. So far as overvoltages are known, bismuth alone fails to conform to the hypothesis. Theoretically it should retard corrosion; actually it is an accelerator. Unless redeterminations of the overvoltage of bismuth and the single potential of iron shall reconcile theory with fact, the author's hypothesis fails. The overvoltage of bismuth was presumably measured on a solid electrode. Bismuth deposited as a powder. If there is the same difference in overvoltage for bismuth as between smooth and spongy platinum, this correction would put bismuth in the list of accelerators.

The statements which follow are intended to apply only to the corrosion of iron by sulphuric acid.

Tin, chromium and mercury retard corrosion; of these tin alone is as effective as arsenic. The protective action of mercury is very slight.

In studying the effect of different reagents on corrosion it is necessary to consider both the metal and the non-metal or acid radical, since each may have an effect of its own.

The binary salts and acids of the halogens are very good protective agents when used in considerable amounts. To combine most effectively the protective effects of a metal and a halogen, *e.g.*, tin and chlorine, much stannous chloride should not be added, for a large amount of the salt of any metal which precipitates on iron in an acid solution is likely to act as a corrosive agent; only a small amount of stannous chloride should be added, and the extra chlorine added as sodium chloride.

Oxidizing agents are in themselves accelerators of corrosion by acids, although in dilute solution this may be masked by a protective action which supervenes when the oxygen has been used up, as might happen with chromates.

Reducing agents should show more or less protective action, but this fact remains to be confirmed by further experiment.

The paper was discussed by Messrs. Hering, Cushman and Walker.

After a vote of thanks to all who had made the Boston meeting so successful and enjoyable the meeting adjourned.

#### Excursions and Social Functions.

The afternoon of Thursday was devoted to two alternative excursions. One was to the works of the General Electric Company at Lynn, Mass., where both the River Works and the West Lynn Works were visited. The other excursion was made to Worcester, where the 15-ton Heroult electric steel furnace at the plant of the American Steel & Wire Company was seen while being tapped and charged again and a visit was paid to the works of the Norton company, where the manufacture of alundum abrasives and refractories was shown. The management of the Norton company must be congratulated on the admirable way in which the visit was arranged.

On Thursday evening, after the lecture by Professor Cross, a smoker at the Tech Union was greatly enjoyed.

Here are two samples of electrochemical poetry. From a poem on "Les Immortels" (Dr. Baekeland, Dr. Whitney, Dr. Walker and Section Q) we quote the Whitney verse: "Where all the volts and args and watts and joules and ohms and dynes—Are concentrated into one with integration signs—You add one hundred million amps and calories galore—And make a man who works all day, and then he works some more:—It's Dr. Whitney—Our Dr. Whitney,—He lights the nights

as tho' 'twere perfect day.—With much reluctance—He talks conductance,—And what is more, he makes the damn thing pay."

From F. E. G.'s electrochemical love song at least the first verse should be given: "Sue, dear, turn off the tungstens, why fear the night?—At ten centimes a kilowatt, let's save the light.—My love shines luminescent,—Your lamps are glowing blue incandescent,—Love loves the dark,—We two need no watt-candles, my flaming arc."

On Friday evening an informal subscription dinner was held at the Hotel Vendome. Dr. Walker was an admirable toast master and speeches were made by Dr. Whitney, Dr. Miller, Dr. Richards, Dr. Bancroft, Dr. Millikan and Dr. Richardson.

In the following we give a complete list of the names of members and guests who registered:

Paul O. Abbe, New York, N. Y.; C. L. Allen, Worcester, Mass.; Richard Amberg, East Orange, N. J.; W. C. Arsem, Schenectady, N. Y.; Walter Arthur, Schenectady, N. Y.; T. F. Baily, Alliance, O.; Wilder D. Bancroft, Ithaca, N. Y.; A. N. Barron, Cleveland, O.; Mr. and Mrs. Fred M. Becket, Niagara Falls, N. Y.; E. H. Bedell, New York City; C. W. Bennett, Ithaca, N. Y.; S. R. Bergman, Lynn, Mass.; E. R. Berry, Malden, Mass.; Reinhard Beutner, New York; Arthur A. Blanchard, Boston, Mass.; Warren F. Bleecker, Canonsburg, Pa.; P. A. Borch, Worcester, Mass.; John C. Bradley, Waterbury, Conn.; Wm. C. Bray, Boston, Mass.; J. W. Brown, Cleveland, O.; L. C. Brown, Lynn, Mass.; C. F. Burgess, Madison, Wis.; J. H. Byrne, Cleveland, O.; M. J. Callahan, Pittsfield, Mass.; W. A. Carter, Lynn, Mass.; C. R. Cary, Philadelphia, Pa.; A. L. Chesley, Boston, Mass.; R. T. Childs, New York, N. Y.; F. M. Clafin, Lynn, Mass.; Jesse Coates, Coatesville, Pa.; F. Parkman Cohn, Schenectady, N. Y.; T. E. Crossman, New York, N. Y.; R. W. Davis, Jr., Wyandotte, Mich.; Mr. C. Davison, Pittsburgh, Pa.; Carl F. Dietz, Worcester, Mass.; Chas. A. Doremus, New York, N. Y.; Boyd Dudley, Jr., Rolla, Mo.; L. H. Duschak, Corning, N. Y.; James H. Ellis, Covington, Ky.; C. G. Fink, Harrison, N. J.; Mr. and Mrs. F. A. J. Fitz Gerald, Niagara Falls, N. Y.; Wm. R. Fleming, Newport, Ky.; Karl Georg Frank, New York, N. Y.; Milton W. Franklin, Schenectady, N. Y.; F. E. Gallagher, Boston, Mass.; Jos. J. Geretz, Philadelphia, Pa.; A. E. Gibbs, Wyandotte, Mich.; Miss M. E. Gibbs, Wyandotte, Mich.; A. McK. Gifford, Pittsfield, Mass.; Miss P. L. Gifford, Schenectady, N. Y.; John B. Glaze, Boston, Mass.; J. S. Goldbaum, Philadelphia, Pa.; Luis R. Gonzalez, Boston, Mass.; H. M. Goodwin, Boston, Mass.; J. S. Gravely, Wytherville, Va.; M. L. Griffin, Rumford, Me.; J. R. Griffith, Niagara Falls, N. Y.; L. J. Guay, Lynn, Mass.; C. A. Hansen, Schenectady, N. Y.; L. O. Hart, Harrison, N. J.; I. S. Hartman, New York, N. Y.; M. W. Hedden, Boston, Mass.; Carl Hering, Philadelphia, Pa.; Mr. and Mrs. Henry D. Hibbard, Plainfield, N. J.; Aldus C. Higgins, Worcester, Mass.; A. T. Hinkley, Niagara Falls, N. Y.; A. Hirsch, New York, N. Y.; C. Vey Holman, Bangor, Me.; A. H. Hooker, Niagara Falls, N. Y.; Henry Howard, Brookline, Mass.; L. E. Howard, Lockport, N. Y.; O. T. Hunznerford, Belleville, N. J.; Mr. and Mrs. Alois von Isakovics, Monticello, N. Y.; Miss Marie von Isakovics, Monticello, N. Y.; Dugald C. Jackson, Boston, Mass.; W. McA. Johnson, Hartford, Conn.; H. T. Kalmus, Kingston, Ont.; R. M. Keeney, Somerville, Conn.; M. M. Kahn, New York; A. Laib, Philadelphia, Pa.; M. O. Lamar, Schenectady, N. Y.; F. C. Lanzenberg, Athens, O.; S. H. Lawton, Boston, Mass.; F. A. Lidybury, Niagara Falls, N. Y.; Stewart I. Lloyd, University, Ala.; D. A. Lyon, Cambridge, Mass.; R. P. MacPherson, Pittsfield, Mass.; J. P. Maffield, Cambridge, Mass.; R. D. Mailey, Boston, Mass.; Paul R. Mahan, Walpole, Mass.; C. W. Marsh, New York, N. Y.; Arthur C. Melcher, Boston, Mass.; L. M. Miller, Schenectady, N. Y.; W. Lash Miller, Toronto, Ont.; R. A. Millikan, Chicago, Ill.; J. P. Minton, Peoria, Ill.; Thomas A. Mitchell, North Waburn, Mass.; Edward Mueller, Boston, Mass.; J. M. Muir, New York, N. Y.; Geo. J. Niebuhr, Newark, N. J.; P. G. Nutting, Washington, D. C.; L. G. Odell, Newtonville, Mass.; Mr. and Mrs. G. S. Page, Pittsburgh, Pa.; Walter O. Patrick, Boston, Mass.; H. D. Pease, New York, N. Y.; John C. Pennie, New York, N. Y.; N. Petinot, Niagara Falls, N. Y.; W. B. Pritz, Cleveland, O.; Mr. and Mrs. E. Quintard, Schenectady, N. Y.; Merle Randall, Poplar Bluff, Mo.; Jos. W. Richards, South Bethlehem, Pa.; F. W. Robinson, Newark, N. J.; E. P. Roebber, New York, N. Y.; Mr. and Mrs. W. E. Ruder, Schenectady, N. Y.; S. P. Sadtler, Philadelphia, Pa.; Pedro G. Salom, Philadelphia, Pa.; R. N. Sargent, Perth Amboy, N. J.; L. E. Saunders, Niagara Falls, N. Y.; Walter H. Sawyer, Lewiston, Me.; Carl G. Schluederberg, Pittsburgh, Pa.; Mr. and Mrs. J. A. Seede, Schenectady, N. Y.; S. Sharoles, Cambridge, Mass.; C. E. Skinner, Pittsfield, Pa.; W. C. Slade, Pittsfield, Mass.; Acheson Smith, Niagara Falls, N. Y.; H. Clyde Snook, Philadelphia, Pa.; E. C. Sprague, Niagara Falls, N. Y.; John Stone Stone, Boston, Mass.; W. Svkes, Pittsfield, Pa.; H. P. Talbot, Boston, Mass.; Mr. and Mrs. F. H. Taylor, Boston, Mass.; Mr. and Mrs. Edw. R. Taylor, Penn Yan, N. Y.; B. F. Thomas, Chattanooga, Tenn.; M. de Kay Thompson, Boston, Mass.; C. B. Thwing, Philadelphia, Pa.; Mr. and Mrs. C. P. Townsend, Washington, D. C.; Samuel A. Tucker, New York, N. Y.; Louis F. Underwood, Lynn, Mass.; M. Unger, Pittsfield, Mass.; G. D. van Airdale, New York, N. Y.; Wm. H. Walker, Boston, Mass.; I. E. Ward, Rumford, Me.; M. A. Williamson, Worcester, Mass.; Mr. and Mrs. J. Patrav Wilson, Niagara Falls, N. Y.; E. Weintraub, Lynn, Mass.; A. Berv Werby, State College, Pa.; W. R. Whitnev, Schenectady, N. Y.; W. J. Wooldridge, Pittsfield, Mass.; E. P. Young, Boston, Mass.; Jno. A. Yunk, South Orange, N. J.

Gold in bituminous coal is reported by the Geological Survey in connection with a treatise on Wyoming coal. It appears that the coal from the mines about Cambria, Wyo., has been found to carry gold to the value of \$2 per ton. When coke made at Cambria was selling at \$3.50 per ton, samples were assayed for gold and silver and found to contain \$2.46 in gold and \$0.28 in silver per ton.



## Notes on Chemistry and Metallurgy in Great Britain.

(From our Special Correspondent.)

### Sequels of the Coal Strike.

Some consequences of the colliers' strike which in all probability were quite unanticipated by the miners and their blind-guide "leaders" promise to form the initial chapter of the lesson of which both the strikers and the agitators stand so greatly in need, namely, that—as Sir William Ramsay indicated in a recent speech—the coal miners are not altogether indispensable, at all events in their present numbers.

A dispassionate, careful and detailed consideration of Sir William's suggestion for converting the coal into gas *in situ* and drawing off the gas for utilization at the surface in the production and distribution of electrical energy, and in other obvious ways, is not likely to flush even the most ardent advocate of the conversion of our coal mines into gas-wells with great hopes of success; but a small mine has been placed at Sir William's disposal, and it is understood that the practical experiment will be tried in the coming summer; so let those who are inclined to hasty judgment remember that the promise of rapid steam locomotion was at first received with incredulity and derision, and that this is far from being a solitary instance of projects which even men of science regarded as unrealizable having been achieved and having passed into the category of everyday commonplaces.

In the region of fact there are clear indications that our manufacturers who can dispense wholly or in part with the use of coal do not intend to be so completely dependent on its supply as they have been hitherto. Many small and moderate consumers of power have placed orders for electric motors; and there is every prospect of their example being extensively followed by larger firms as soon as the foundries can supply castings. Inquiries for oil engines promise to increase very considerably, and steam raising by liquid fuel is advancing. The power-house of the Liverpool Corporation is being equipped by a well-known liquid fuel apparatus company, as is also Messrs. Harland and Wolff's power house at Belfast, while several factories are being supplied with the same or similar plant. Compressed oil fuel is passing favorably through the experimental stage; and its low cost and superior calorific value are practically certain to ensure an immediate and growing demand.

Finally, several mines in which the remaining coal would only suffice for a year's working or so, together with a larger number of pits where the nature of the seams entails high working costs are, or will be, permanently closed, with the result that some thousands of men who were earning very good wages will, until they can find other employment, have leisure to reflect on their want of foresight.

### The Volatility of Metals of the Platinum Group.

At the meeting of the Royal Society early in March a paper on this subject was read by Sir William Crookes, who said he had noticed that the coil of platinum foil in a small electric resistance furnace became thinner with use until it fused at the weakest spot. He then discovered on the porcelain tube a fine deposit of well-formed brilliant metallic crystals which were analysed and found to be platinum. The loss of weight on a platinum crucible heated to 1300 deg. C. for 30 hours in an electric furnace was then determined and found to be 0.245 per cent.; palladium heated to the same temperature for the same time lost 0.745 per cent; and an iridium crucible heated to 1300 deg. C. for 22 hours lost more than 0.7 per cent, while at higher temperatures the loss was greater and proportional to the temperature. The surface of the iridium crucible had assumed a crystalline appearance at the beginning of the latter series of tests, and at the conclusion the edges exhibited incipient disintegration and crumbled when handled with forceps.

Rhodium showed a loss of 0.13 per cent in 30 hours at 1300 deg. C.—about half that of platinum.

At 900 deg. C. in the flame of a Méker burner, platinum and rhodium suffered no loss after 20 hours; but palladium and iridium lost in 10 hours 0.0919 per cent, and 0.091 per cent respectively.

The volatilization of iridium at high temperatures *in vacuo* was effected by placing a weighed quantity of the pure clean metal in a fused silica bulb-tube which was then exhausted and heated nearly to redness until moisture and occluded gases were entirely eliminated; the drawn out end was sealed off, and the tube was placed in a suitable position in an electric furnace where the bulb was heated to 1300 deg. C. for 30 hours. When cold the bulb and the neighboring parts of the tube were observed to have become devitrified and opalescent; and on the less heated portion there was a black deposit which was found on examination to be metallic iridium.

There is little, if any thing, of new discovery in these results. The unsuitability of the platinum and platinum-iridium thermocouple for temperatures over 1000 deg. C. has for years been suspected to be due to volatilization of the iridium; and in at least one not very recent paper dealing with pyrometry the volatility of this metal has been definitely asserted.

It is fairly well known, too, that platinum loses weight by prolonged exposure to the highest temperatures obtainable in a muffle.

### Dielectric Resistance with Alternating Currents.

At the meeting of the Institution of Electrical Engineers on the 28th of March, a paper by Professor J. A. Fleming and G. B. Dyke "On the Power Factor and Conductivity of Dielectrics When Tested With Alternating Electric Currents of Telephonic Frequency at Various Temperatures" was read.

It was a noteworthy contribution to electrical knowledge, and deserves the attention of all who have to deal with insulation problems, particularly in relation to alternating emf of low voltage of pure sine-wave form, with frequencies from 900 to 5000. The summary states that the alternating-current dielectric constants of crown glass, celluloid, dry Manila paper, paraffin, ebonite, and mica are of the same order as those obtained with unidirectional electric force; but pure and vulcanized rubber and gutta percha give lower values. The general agreement of the constants found by the authors' methods with those obtained by other methods indicate that their measurements are accurate. It is shown that whereas the power factor of vulcanized rubber at ordinary temperatures is only one-tenth of that possessed by gutta percha yet its alternating-current resistivity is ten times as great as that of gutta percha; and, therefore, the ratio of conductivity to capacity (S/C) is ten times smaller at about 18 deg. C. The figures given in the text-books for the dielectric resistance of gutta percha as used on cables at 75 deg. F. and for pure rubber at 15 deg. C., per cubic centimeter, after one minute, are nearly 100,000 times greater than the real alternating-current resistivity for the telephonic standard frequency of 800 p.p.s.

The following conclusions are among those arrived at by the authors: (1) All the dielectrics so far tested prove to possess a true dielectric conductivity for alternating currents considerably greater than for steady unidirectional currents (2) This increased conductivity implies greater power dissipation for the same terminal potential difference or voltage (3) The alternating-current conductivity increases with the temperature except in the case of vulcanized india rubber rather below 20 deg. C., and gutta percha rather above 15 deg. C., in both of which cases it decreases with rise of temperature. In the case of mica and very dry paper it is not affected to any sensible extent by rise of temperature over a range between 0 deg. C. and 60 deg. C. (4) The alternating-current conductivity is in most cases a linear function of the frequency and may be expressed in the form  $a + b n$ , where  $a$  and  $b$  are coefficients which are functions of the temperature and  $n$  is the frequency. (5) The



alternating-current conductivity, especially that part of it denoted by  $a$ , is greatly increased by the presence of moisture in the dielectric. This part is probably identical with the true direct-current conductivity. (6) The part of the conductivity denoted by the coefficient  $a$  is possibly electrolytic in nature, while the part proportional to the frequency is a consequence of an energy loss which is possibly analogous to the hysteresis loss in iron.

#### The National Physical Laboratory.

At the meeting of the General Board, in the middle of March, the report for 1911 was presented; but it has not yet been issued. In the department of metallurgy the researches on aluminium-zinc alloys and aluminium-zinc-copper alloys were continued, and investigations were carried out on the melting point of iron; the effect of stress at high temperatures; the microstructure of steel at high temperatures; and the causes of brittleness in steel. Experiments on the spontaneous combustion of charcoal yielded very interesting results. With an air supply ranging from 5 to 62 cubic feet per minute to 1 cubic foot of flaked charcoal spontaneous combustion took place at temperatures varying with the rate of air supply from 96 deg. C. to 110 deg. C.; but below 96 deg. C. no rise of temperature was observed in the charcoal. With air containing 5 per cent of sulphur dioxide, spontaneous ignition of charcoal resulted at the temperature of the air, about 18 deg. C.; but samples of decayed wood were far less readily acted on.

#### Ferrosilicon Explosions.

A. von Gumberz (*Stahl und Eisen*, 1912, 32, p. 267) has investigated two cases of explosions which followed the addition of ferrosilicon to molten steel. In both cases fully 25 minutes elapsed after the ferrosilicon was added before explosion occurred in the ladle. In one case the precautions included the previous raising of the ferrosilicon to a red heat and the thorough heating of the ladle; consequently the presence of residual paraffin on the surface of the ferrosilicon or of gases and moisture could not be suggested as a probable cause. Research established the fact that at a red heat ferrosilicon and copper oxide react exothermically with production of metallic copper and silica. The heat evolved is described as "considerable"; and the suggestion is made that a possible cause of the explosions may be a reaction of the same nature between the ferrosilicon and the iron oxides existing in the slag; but this point remains to be determined.

#### English Petroleum.

The *Electrical Review* of the 29th of March, announces, in a communication from Mr. W. H. Booth, that petroleum has been found in two spots in England. Near Woking, the lower green-sand was reached at a depth of 1571 ft., closely approximating to the mean of the limits Mr. Booth estimated. At present no information has been vouchsafed as to the yield; but, as the discovery is now some weeks old, it is not probable that any great flow has been tapped.

#### Estimation of Manganese in Ferro-Tungsten.

P. Slawick (*Chem. Zeit*, 1912, 36, 106) heats a mixture of one gramme of the finely divided sample with ten grammes of sodium peroxide for about 3 minutes in a porcelain crucible at a dull red heat; after cooling, extraction with water, and cautious acidification with hydrochloric acid, the liquid is boiled for 15 or 20 minutes with a large excess of hydrochloric acid, a slight excess of zinc oxide added, and the whole boiled up and titrated with permanganate. The method has the advantage of rapidity, and the error indicated by a check analysis by another method amounts to 0.02 per cent on an alloy having a manganese content of 0.47 per cent.

#### Engineering Imports and Exports.

The returns issued by the Board of Trade for January and February compare very favorably with those for the corresponding period of last year, and show substantial increases all

around except in imports of new ships, which decreased. The month of February taken alone exhibits a similar improvement. For the two months the imports of iron and steel, including manufactures, are valued at £2,021,532, and exports at £7,907,437 and the respective increases are £332,020 and £711,027. Imports of other metals, including manufactures, reached £5,037,991, an increase of £719,357, with exports £1,877,272, an increase of £169,086. Electrical goods were imported to the value of £274,991, an increase of £43,442; while exports amounted to £528,080 showing an improvement of £99,356. In machinery the imports touched £1,024,516, and the exports are put at £5,013,298, the respective increases being £139,604 and £298,852. Imports of new ships amounted to only £507, a fall of £36,585; but the exports, valued at £711,714, increased by £90,867.

#### Market Prices.

##### March, 1912.

Copper has risen considerably throughout the month. Starting at £64.10.0 it was at £65.5.0 by the 5th, then fell away to £64.5.0 by the 11th, recovered 13th, and lost slightly on the 18th. Since then the rise has been rapid, and it now stands at £68.5.0.

Tin has been credited with a "boom," which does not seem an altogether accurate description, the highest price this year being £202, and the lowest £191. Opening at £199 it closes at £198.

Lead has shown a decided upward tendency. Starting at £16.4.0 it was much the same on the 13th, but has since risen steadily to £16.10.0.

Haematite has risen, iron generally being affected by the limited production. Opening 64/6 it closes at 66/-.

Scotch Pig has risen smartly from 55/6 to 56/8 by the 14th and 57/- on the 18th, closing at 58/-.

Cleveland follows much the same course as Scotch Pig, starting 49/6 and reaching 51/8 on the 18th, it closes at 51/3.

India-Rubber has been higher, and with some tendency to harden. Opened 4/8, closes 5/-.

A general rise in metals is evidenced, consequent on limited production throwing the market back on stock.

	£ s. d.
Alum lump, loose, per ton.....	5.15.0
Antimony, black sulphide powder per ton.....	20. 0.0
Borax, British Refined Crystal, per ton.....	16.10.0
Copper Ore, 10 to 25%, per unit, 11/4 to.....	11.10½
Copper Sulphate, per ton.....	22.17.6
Carbolic Acid, liquid 97/99 per cent per gal.....	1.8
Creosote, ordinary good liquid, per gal.....	2¼
Camphor, 1 oz. tablets.....	1.7½
Caustic Soda, Ash 48% ordinary, per ton.....	5.10.0
Hydrochloric Acid, per cwt.....	5.0
Mica, small sheet, original cases, per lb.....	6d to 2.0
Napha, solvent, 90%, 160 deg. C., per gal.....	8¾
Petroleum, Russian spot.....	9¼
Quicksilver, per bottle.....	8.12.6
Sal Ammoniac lump, firsts, delivered U.K. per ton....	42. 0.0
Sulphate of Ammonia, f.o.b., Liverpool, per ton....	14.10.0
Sulphur, recovered per ton.....	5. 0.0
Shellac, Standard T. N. Orange spots, per cwt.....to 4.	4. 4.0
Tin Ore, 70% per ton.....	£123.0.0 125. 0.0
Zinc, Viella Montagne, per ton.....	28. 5.0
Platinum, nominal.....	9. 5.0

The differences on the month are thus:

##### Higher.

	£ s. d.
Copper Ore, per unit.....	6
Creosote, per gal.....	0¼
Petroleum, Russian, per gal.....	0¼
Quicksilver, per bottle.....	5.0
Lead, per ton.....	6.0
Scotch pig, per ton.....	2.6
Cleveland, per ton.....	1.9
India-rubber, per lb.....	4

## Recent Metallurgical and Chemical Patents

### Iron and Steel.

**Titanium Treatment of Steel.**—Mr. AUGUSTE J. ROSSI, the untiring worker on titanium, suggests that the usual universal use of ferrosilicon and ferromanganese in connection with the Bessemer converter, open hearth, and crucible processes can be dispensed with, if a treatment with ferrotitanium is substituted for it. For instance, in the case of the Bessemer converter process, after the metal has been blown, it is recarbonized either in the converter or intermediate ladle by any of the well-known recarbonizing methods other than by ferromanganese or spiegeleisen. To the metal thus recarbonized he then adds, preferably in the intermediate ladle, such an amount of ferrotitanium as to satisfy the affinity of titanium for all undesired elements and compounds present. He then pauses in the operation for a time determined to insure all the reactions possible with the titanium, after which the metal may be poured and cast into ingots as usual. The absence of manganese and silicon is stated not to impair the tensile strength. From ordinary steel the product of this process is distinguished as it contains some titanium (less than 2 per cent being claimed), but much less manganese and much less silicon, if any more than traces, and less carbon. "Notwithstanding it may contain only a moderate percentage of carbon, say for example not to exceed 0.5 per cent, its tensile strength is as great or greater than though it had contained the heretofore usual percentages of manganese and silicon required, for instance, in steel used for rails." (1,017,807, Feb. 20, 1912.)

**Hot-Blast Stove.**—A patent of Prof. WALTER MATHESIUS, of Charlottenburg, Germany, relates to the construction of a hot-blast stove in which the combustion chamber is arranged centrally, so as to reduce the loss due to heat radiation, and is

surrounded by concentric annular flues through which the gases pass in a zig-zag course, an inner cupola or dome being provided within the usual outer cupola. Heretofore, the practical utility of such a construction has been frustrated owing to the fact that the inner cupola was not held rigidly in position independently of the walls of the flues, but was carried by the latter, so that the flue walls were subjected to too great a load, which resulted in leakages and in a diminished efficiency of the stove. In the construction of Mathesius one or more of the flues are con-

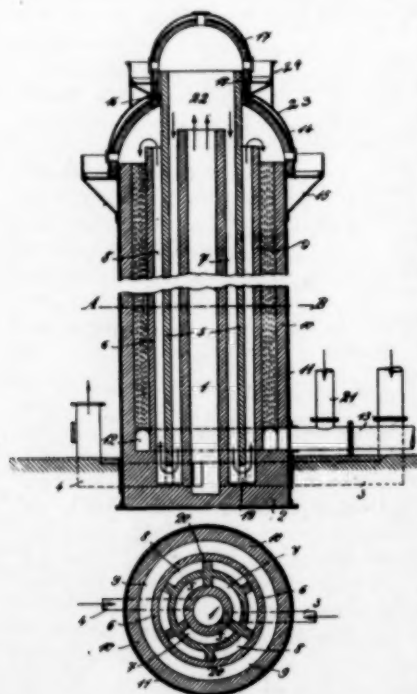


FIG. 1.—HOT BLAST STOVE.

tinued upwardly through the outer or larger cupola, and a smaller cupola is fitted on the top of the elongated flues, a tight stuffing-joint being formed between the elongated flues and cupolas. The latter are moreover carried by the outer iron shell of the stove so that the flue walls

only require to support their own weight. In order to create as long a flame as possible in the combustion chamber, the furnace gases and the air for combustion are admitted not radially, but tangentially and parallel to one another so that the flame takes a spirally upward course. In Fig. 1 the furnace gases and the air are admitted through the conduits 3 and 4 respectively. Surrounding the combustion chamber 1 are annular flue walls 5 and 6, forming flue spaces 7 and 8, and around the outer flue wall 6 is provided checkered brickwork 9 between the wall 6 and the outer wall 10, which is surrounded by the iron shell 11. Below the checkered brickwork 9 is a flue space 12 communicating through a conduit 13 with the chimney 21 is the cold air-blast inlet. The smaller cupola 17 is only about half the diameter of the cupola 14 so that the radiation of heat from 17 is only about one-fourth that of the cupolas of the Cowper stove now in general use. Further on account of the large space of the combustion chamber, and the spiral path of the gases and air moving in it upwards, the combustion is retarded and local heating is obviated. The temperature of the gases in cupola 14 is said to seldom exceed 800 deg. C. (1,018,331, Feb. 20, 1912.)

**Melting Steel Scrap.**—In connection with a former American Electrochemical Society paper of Mr. ALBERT E. GREENE of Chicago, Ill., on his "electric converter," (our Vol. IX., p. 275) a recent patent of Mr. Greene is interesting. The object is to melt steel rich in manganese, silicon or other alloys with pig iron and convert the mixture into steel, without substantial loss of the alloys. The molten pig iron is charged into an electric furnace provided with twyers for blowing the bath. The manganese-steel scrap or other alloy-steel scrap is then added, and while maintaining the bath molten, the bath is blown with a gas which will decarbonize the metal without substantial loss of alloys, thereby converting the charge into steel. The gas should have a component of a reducing nature with respect to the oxides of the alloying metals and a component of an oxidizing nature with respect to carbon. For this purpose a mixture of CO and CO<sub>2</sub> in suitable proportions should be used. When the scrap consists of metals like manganese, nickel, chromium, etc., a basic furnace may be used. But when the scrap contains acid-forming metals like silicon, tungsten, titanium, vanadium and the like, it is desirable to carry out the process in an acid-lined electric furnace, starting with pig iron suitably free from phosphorus and sulphur. If the pig iron contains too much phosphorus and sulphur, these elements are first removed by charging the pig iron into a basic-lined electric furnace and, after adding lime and fluorspar, blowing it with gas of about the composition of blast-furnace gas, containing 20 to 25 per cent CO and 10 to 15 per cent CO<sub>2</sub>, maintaining the temperature at about 1300° C. At this temperature the phosphorus comes out more readily than carbon. The sulphur may be removed at the same time as calcium sulphide. Mr. Greene has found that the carbon can be removed from a bath of pig iron and manganese-steel scrap with a loss of less than 2.5 per cent of the original content of manganese and that at the same time nearly all the silicon can be retained if desired. (1,018,418, Feb. 27, 1912.)

**Purifying Molten Metal.**—Superheated steam has been used heretofore for the purpose of partly refining and purifying metals by forcing the steam through a molten mass. Mr. WILLIAM H. KELLY, of Los Angeles, Cal., proposes to substitute dissociated steam for superheated steam and treat molten metal with the dissociated gases, hydrogen and oxygen. He generates steam in a boiler and passes the steam through a suitably heated retort where the steam is dissociated. It is then conducted through a suitable tube and nozzle into the molten mass of metal. The inventor claims improvement in purifying by his method. (1,019,965, March 12, 1912.)



**Fire Brick Lining for Furnaces.**—An improved form of furnace brick has been patented by Mr. ALLAN N. H. STRALE, of Chicago. In the ordinary manner of lining furnaces with the brick commonly provided for that purpose, the vertical joints are broken, but the horizontal joints between successive courses

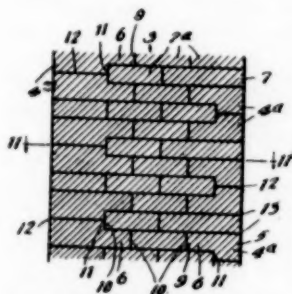


FIG. 2.—FURNACE LINING.

of brick are continuous and comparatively open, so that leaks of gas may occur more easily along those lines. The inventor has designed special forms of brick which, when properly laid, will result in broken and bonded horizontal joints, as well as similarly formed vertical joints. In Fig. 1 is shown the manner of laying the bricks in order to attain this end. (1,021,851, April 2, 1912.)

**Furnace Charging Apparatus.**—In that type of furnace charging apparatus in which a skip or car is periodically loaded, elevated and dumped into a receiving bell hopper, Mr. DAVID BAKER, of Philadelphia, has patented a combination whereby the operation of the upper and lower bells is effected automatically in harmony with the elevation of the skip. By a system of valves and pistons, the upper, or receiving, bell is actuated by the travel of the skip, so that it regularly discharges its contents into the lower bell at each trip of the skip. Control of the lower bell is arranged whereby after a certain number of trips by the skip the former will discharge its contents into the furnace. These operations are controlled by a regulator connected with the hoisting engine. (1,016,539, Feb. 6, 1912.)

#### Gold and Silver.

**Oxidizing Leaching Solution.**—Interesting claims are made for a new combination of chemicals used in the treatment of gold and silver ores in the form of sulphides, tellurides, selenides, arsenides and antimonides. JOSÉ B. DE ALZUGARAY, of New York, is the patentee, and has assigned his invention to the International Metallurgical Company, New York. The chief object of the invention is to produce a combination of chemicals which will be strongly oxidizing in their action, and at the same time act as good solvents for the precious metals. The inventor uses hypobromites, bromates and perbromates as strong oxidizers, in combination with alkali cyanides as solvents for gold and silver. In order to overcome the slow action of cyanide solvents on silver the inventor proposes to add a suitable amount of alkali or alkali-earth chloride, which acts as a silver solvent, forming silver chloride, which is easily soluble in cyanide solutions. As an example of the composition of his leaching solution, the inventor gives the following:

Potassium cyanide .....	0.6
Ferrocyanide .....	0.3
Calcium hypobromite, bromate or perbromite.....	0.1
Sodium or calcium chloride .....	3.0

The same apparatus used in the ordinary cyanide process may be used in applying the above solution. (1,018,955, Feb. 27, 1912.)

**Precipitation by Atomized Lead and Zinc.**—For many years the standard method of precipitating cyanide solutions of gold and silver has consisted in percolating the solution through masses of zinc shavings. More recently, zinc dust, a by-product of zinc smelting, has been used and found generally more efficient than shavings. Still more recently, however, Mr. JAMES M. NEIL, of Toronto, Canada, has proposed the use of finely divided or atomized lead and zinc, prepared artificially. The method of atomizing these metals was described in our issue for March, 1912, page 180. The metals, lead or zinc, are melted and then atomized by a jet of steam or air, and recov-

ered in the form of metallic dust, free from oxide and in prime condition for precipitation of cyanide solutions.

Mr. Neil states that he has found atomized lead to be a more active precipitant than zinc shavings or zinc dust. The atomized metal may be added to the solution in the usual manner, and the quantity used may be varied according to the richness of the solution. The inventor states, also, that a combination of atomized lead and atomized zinc is still more efficient than either metal alone. The best proportion is one part of lead to two or more parts of zinc. When these metals are mixed and agitated with the cyanide solution an electrogalvanic action is set up, which rapidly precipitates the dissolved gold and silver. The zinc goes into solution, but the lead forms part of the precipitate and is of value in the later process of refining by cupellation. (1,018,438, Feb. 27, 1912.)

**Zinc-dust Precipitating Apparatus.**—In Fig. 2 is shown an improved device for accurately proportioning the charge of zinc dust to a definite volume of cyanide solution, and giving the exact time of contact desired before the precipitated solu-

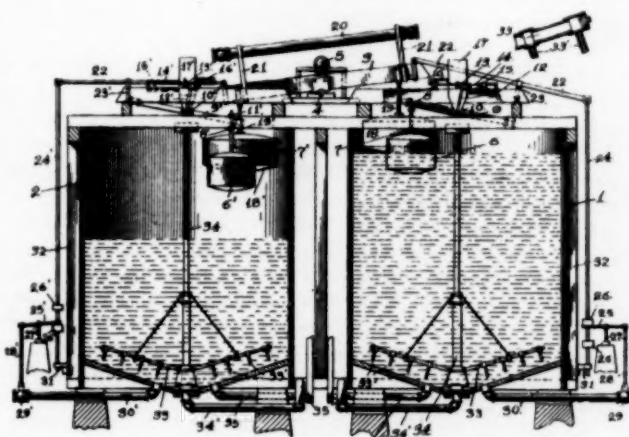


FIG. 3.—ZINC DUST PRECIPITATING APPARATUS.

tion is delivered to the filtering medium. It is the invention of DANIEL BOSQUI, of Gold Road, Ariz., and has been assigned to the Merrill Metallurgical Company, San Francisco, Cal.

The apparatus comprises two tanks into which the cyanide solution can be diverted alternately, feed means for delivering a predetermined quantity of zinc dust to the tanks alternately, and means for agitating the mixture of solution and dust. The several steps in the cycle of the process are controlled automatically, as will be seen from the following description. As the operation of the two tanks is identical, only one will be described.

The cyanide solution enters by way of the pipe 5 and the tilting launder 3. As one of the tanks becomes filled to a predetermined point, according to the time of contact desired, the solution raises the float 6. The float is connected by stem 7 with the tilting lever 9, which is a tube partly filled with mercury. As the inner end of the lever is raised the mercury flows to the opposite end and causes the forked arm 12 to be thrown sharply to one side. This forked arm engages a pin 13 which is attached to the slide arm 14, which in turn carries cutter blades 15 and 16 which move within the zinc dust hopper 17, and periodically discharge therefrom a definite quantity of zinc dust into the solution in the tank.

After the discharge of the zinc dust into the solution the latter continues to run into the tank until it acts on the second float 18, which is connected by the rod 19 with the tilting launder 3. Attached to and placed above the launder is a pipe 20 containing mercury which, in flowing to the lower end of the tube, causes the tilting launder to move and discharge the inflowing solution into the other tank. At the same time the rising end of the launder acts through the lever 22, which is pivoted at 23, and lowers the rod 24 which is connected by



lever 25 and rod 27 with the valve 29 which controls the outflow of solution to the filter. Hence the rising launder diverts the flow of solution to the other tank and automatically opens the valve 29 so that the precipitated solution can flow from the tank to the filter.

An agitator consisting of a vertical support 34, radial arms 33 and nozzles 33' is located in each tank. A centrifugal pump 35 has a suction pipe 35' and discharge pipe 34', the latter entering the agitator as shown. When the pump is in operation it forces the solution into the arms and out of the nozzles of the agitator, causing the latter to revolve in the tank and keep the solution and zinc dust well mixed during the definite period which elapses between the addition of the zinc and the discharge of the precipitated solution.

One of the tanks is filling while the other is being emptied, and the action of the mechanism of one is complementary to that of the other. There is no contact of air and solution except at the surface, and yet there is a thorough mixture of solution and zinc in definite quantities and during a definite period of time. (1,018,604, Feb. 27, 1912.)

**Agitator.**—A combination of the features of air-lift and mechanical agitation has been invented by Mr. CHARLES C. HAFFER, of Phoenix, Ariz. It consists of a rotatable hollow vertical shaft supported at the bottom of a tank in a step bearing and at the top by a beam extending across the tank. Near the top and bottom of the vertical shaft are radial arms which support several vertical air-lift pipes, those on opposite sides of the shaft having their discharge ends curved horizontally in opposite directions. The arms and pipes revolve with the vertical hollow shaft. Extending from the bottom of the latter are air pipes which communicate with the vertical air-lift pipes. In operation air is sent down the vertical hollow shaft and through the lower air pipes into the air lifts. The solution is raised and discharged, the reaction of the discharge causing the agitator to rotate in the tank, thus bringing about air and mechanical agitation. (1,020,694, March 19, 1912.)

#### Copper and Zinc.

**Fusing Cathode Copper.**—In order to fuse cathode copper and obtain a pure product, free from contaminating gaseous substances, Messrs. WALTER S. ROCKEY and HILLIARY ELDRIDGE, of New York, propose to carry on the operation in a furnace with two compartments. Both of these compartments are provided with oil jets. The copper is fused by the oil jet in the first compartment. The molten metal accumulates in a depression in the bottom which serves as a trap and flows by a conduit into the second compartment where it is received in a crucible provided with a conical perforated cover. The lower part of this crucible is in the form of another trap which prevents the ingress of combustion gases from the chamber in which the crucible rests. By keeping the copper molten in the second compartment at a high temperature the gaseous contaminations are removed by volatilization; and as the trap effectually prevents the ingress of any further gaseous compounds, the copper can be collected in a very pure condition. The object of the process is to prevent the very pure cathode copper from being contaminated in remelting. (1,018,681, Feb. 27, 1912.)

**Refining Scrap Copper Alloy.**—A method of obtaining a higher degree of purity in remelted copper alloy than has been possible by former methods is proposed by WALTER S. ROCKEY and HILLIARY ELDRIDGE, of New York. They first fuse a flux of boron trioxide, or one containing that substance, and then introduce the copper scrap. The latter melts beneath the flux and its impurities are dissolved therein. A reducing substance, such as carbon, is then added to the flux for the purpose of further reducing the impurities which may have been dissolved, after which the purified alloy may be separated in any desirable manner. (1,019,524, March 5, 1912.)

**Roasting Copper Pyrites.**—In roasting copper sulphide ores for the purpose of subsequently obtaining the copper by a wet process, it is desirable to carry on the roasting operation

so that the maximum amount of copper shall be produced in a soluble form. CHARLES GABRIELLI, of Paris, France, has proposed a method of roasting in which the gases can be used for the manufacture of acid and the residue be left in good condition for wet extraction. This process consists in adding to the dead-roasted pyrites a certain quantity of green pyrites at that part of the furnace hearth where the temperature is higher than that at which the sulphate of iron will decompose, but lower than that at which copper sulphate would decompose. A soluble sulphate of the copper is thus formed, while the iron is left in an insoluble form. The inventor claims that this method of roasting will give a higher yield of copper than is obtained by present methods, while at the same time the process does not interfere with the recovery of sulphuric acid. (1,018,609, Feb. 27, 1912.)

**Treatment of Copper Ores.**—The use of a wet process as an adjunct to ordinary concentration of ores is proposed by Dr. RUDOLF GAHL, of Morenci, Ariz. The inventor cites the well-known losses suffered in concentration, and suggests the use of a wet process to recover metal which now is lost. In carrying his invention into effect he crushes the ore finely enough to liberate all the mineral from gangue, and makes no particular effort to prevent the formation of slime. The coarse sand tailing resulting from concentration is usually clean enough to be discarded at once, but the slime tailing is treated by the proposed wet process. This consists in leaching the tailing with ferric sulphate, which can be prepared cheaply according to several methods indicated by the inventor. Some mine waters carry ferric sulphate in solution; ferruginous smelter slags can be treated with the sulphurous and sulphuric acids contained in the waste gases; scrap iron can be treated with sulphuric acid; iron oxide ore can be mixed with the charge and leached with sulphuric acid, or the iron oxide ore can be treated with the acid first and the resulting solution used for leaching.

Where the iron sulphate is already in the ferric condition it can be used directly, but it must be oxidized if in the ferrous condition. The oxidation can be carried on in several ways. The ferrous solution can be evaporated in reservoirs in the open air, yielding a dry salt in a more or less oxidized state which, when exposed to heat at the proper temperature, will yield basic ferric sulphate. Or the ferrous salt can be precipitated by lime, and the precipitate oxidized by blowing air through the mixture. Or, finally, the ferrous salt obtained by evaporation can be heated above the point of decomposition of basic ferric sulphate, yielding iron oxide and sulphuric acid anhydride, the latter being dissolved and used to leach the iron oxide.

Modifications may be introduced in the process, such as using salt, bleaching powder, nitre, manganese peroxide or the like, for facilitating the solution of the copper. In leaching low-grade slime containing about 1 per cent of copper, the concentration of ferric iron in the solution will be less than 1 per cent, and the quantity of sulphuric acid may attain or exceed 1 per cent.

The process described above, or other processes in which solutions are used to dissolve the metal to be recovered, may be carried out to advantage in the following manner, as illustrated in Fig. 3. This is an adaptation of the decantation system, in which, however, provision is made to have the solvent flow counter to the ore. In the figure the solid line indicates the line of flow of the ore and the dotted line shows the flow of solution. The letter *D* indicates tanks in which solution takes

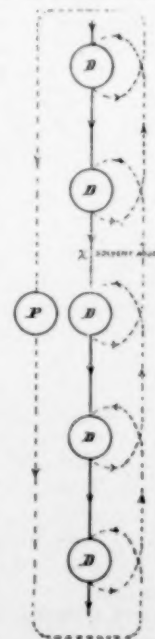


FIG. 3.—DIAGRAM OF PROCESS OF TREATING ORES.

place and *P* represents some form of precipitating apparatus. By this system, in which the solvent is added at some point intermediate the head and tail of the system, nearly exhausted pulp is treated with fresh leaching liquor, and fresh pulp is brought in contact with partly exhausted leaching liquor. At the same time the liquor flowing from the precipitating plant is used for finally washing the pulp in, the last tank in the series. In this system, also, heat may be applied to the solu-

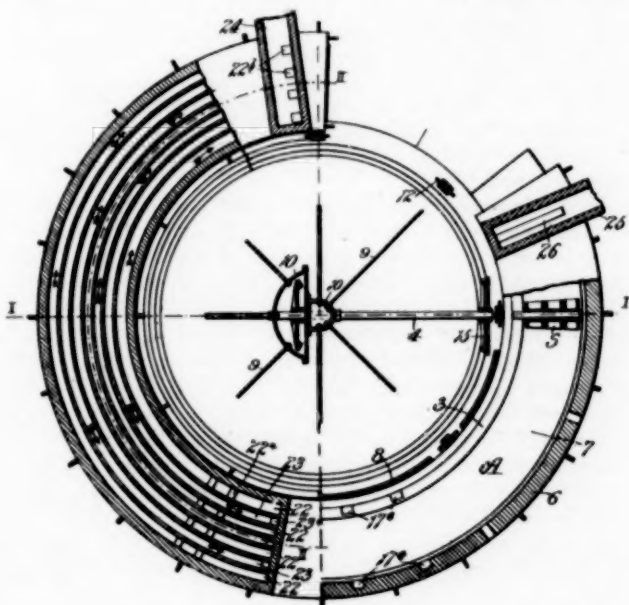


FIG. 5.—RECUPERATIVE ZINC ORE ROASTER.

tions at one point, for example, where the solvent is added, and be distributed throughout the entire plant, heating the incoming ore. Thus the loss of heat will be as small as possible. (1,021,768-9, April 2, 1912.)

**Recuperative Zinc Ore Roaster.**—According to letters patent recently granted to Mr. JOHN ZELLWEGER, of St. Louis, Mo., the inventor has designed a furnace for roasting zinc sulphide ores, in which a large percentage of the sulphur dioxide will be separated from the fire gases in the kiln and delivered in concentrated condition for acid manufacture. The design further provides a recuperator in which the outflowing gases of combustion are caused to give up heat to inflowing air used in roasting. The roasting furnace is circular in shape, except that the circle is broken between the charging and discharging ends. As shown in Fig. 5, the furnace is divided, roughly, in two parts, lying one on each side of the vertical line drawn through the figure. The annular hearth is shown at *A*, and the traveling rabble, which is constructed of several sections mounted on a shaft, is shown at *S*. The front or feed end of the furnace is the right half of the figure, and the discharge or back end is on the left. Burners are used only in the back end, where extraneous heat is necessary to finish the desulphurization. The ore in the front half burns due to its own fuel which is oxidized by heated air drawn in through the recuperator above the back end of the furnace where the fuel burners are placed. The recuperator is shown in the left half of the drawing as a series of flues through which the furnace gases and air flow in opposite directions, as shown by the arrows.

At the discharge end of the furnace is a stack 24 through which the gases of combustion from the burners pass, being drawn into the stack through flues at 22a and flowing to 22b, where they enter the stack. Thus the products of combustion of the fuel is removed from the furnace without mingling with the sulphurous acid fumes which are coming off at the front end of the furnace.

At the front end of the furnace is another stack 25 and fan

26. The fan draws air through the air ducts in the recuperator, the outer ends of which are open to the atmosphere and the inner ends open to the furnace kiln at 23. Thus heated air is provided for the combustion of the sulphur in the ore, forming sulphur dioxide, which is drawn by the fan through the front half of the furnace and up the stack 25, whence it can be delivered to acid chambers.

It will be seen that this arrangement provides for the removal of most of the sulphur from the ore while it is in the front half of the furnace, where it is not in contact with products of fuel combustion, while the back half of the furnace provides for the final removal of the sulphur content of the ore, and the elimination of this small quantity of sulphurous gas with the products of combustion through the ducts 22 in the recuperator and stack 24. This design results in a sort of neutral zone in the furnace between the points 22a, where the outflowing gases enter the recuperator, and 23a, where the incoming air is discharged from the recuperator in to the front of the furnace. The gases in this neutral zone can be made to flow one way or the other by varying the quantity of air entering through the recuperator. (1,017,839, Feb. 20, 1912.)

#### Tin.

**Detinning Process.**—The recovery of tin from tin scrap and old tin cans has been accomplished successively by electrolysis and by chlorine. Electrolysis was the first successful process, yielding metallic tin and steel suitable for open-hearth refining. The chlorine process succeeded the electrolytic and gave as products tin tetrachloride (anhydrous) and steel scrap. Both of these processes have been used extensively at the Goldschmidt works in Essen, Germany, and were described in detail in our issue for February, 1909, page 79.

A new method of detinning has been patented by Dr. JOSEF WEBER, of Essen, Germany, and assigned to the firm of Th. Goldschmidt. The process consists in treating tin scrap with an alkaline solution containing an oxidizing agent, as saltpeter. The sodium stannate thus formed is decomposed into tin oxide and sodium carbonate by the addition of sodium bicarbonate to the sodium stannate solution. The sodium carbonate is rendered caustic by treatment with lime, and is suitable for use in dissolving more tin.

The process is carried out as follows: The material, after having been subjected to suitable cleansing processes, is brought into a solution containing, say, 20 per cent by weight of sodium hydroxide and 10 per cent by weight of saltpeter. The solution is boiled for about three hours, after which the metal is removed and given a similar treatment in a second bath. Following the second solution the material is given to separate water washes. The detinning baths are used until crystals of sodium stannate begin to form in the first bath, whereupon the second bath is then used as first bath, and a fresh solution is substituted as second bath. The solution which has been saturated with sodium stannate is then concentrated to a sp. gr. of 1.4, when nearly all the sodium stannate will crystallize out. These are removed, treated centrifugally, and subjected to further action for the precipitation of tin oxide. The mother liquor is then made up to proper strength and used as solvent again.

The crystals of sodium stannate are dissolved in water, and sodium bicarbonate is added in order to precipitate tin oxide. The solution of soda which results is then made caustic by treatment with lime, and after being made up to proper strength is again ready for use. The saltpeter is not lost as it remains in the solution. Thus a pure oxide of tin is produced and the chemicals required for its production are recovered. (1,018,734, Feb. 27, 1912.)

#### Tungsten and Vanadium.

**Tungsten Lamp Filaments.**—In the production of hydrogenous and nitrogenous tungsten, uranium, etc., by means of strongly reducing metals, such as magnesium or aluminium, explosions occur which may be dangerous. It is the object of



an invention of Mr. HERMANN ZERNING, of Halensee, near Berlin, Germany, to so reduce tungsten and other metals without encountering the danger from explosions. His method consists in, first, using a reducing metal which has a lower affinity for oxygen than is exhibited by magnesium or aluminium. Zinc is such a metal. The partly reduced compound obtained by this reduction can then be submitted to the action of magnesium or aluminium for final reduction. The metals thus reduced, which form a hydrogenous or nitrogenous compound, can be freed from admixture of metallic oxides as well as from zinc and aluminium by the use of acids, and the resulting product is claimed by the inventor to be in a very suitable condition for the manufacture of electric lamp filaments by first mixing with a plastic substance and then pressing into filament form. (1,019,581, March 5, 1912.)

**Recovery of Vanadium as Vanadic Acid.**—A process for treating any of the vanadium ores has been patented by BYRAMJI D. SAKLATWALLA, of Bridgeville, Pa., and assigned to the American Vanadium Company, of Pittsburgh. The process consists in grinding the ore to a suitable degree of fineness, say, to 60 or 80 mesh, and treating the pulp with 1:1 sulphuric acid. The extraction is made with the application of heat and the use of steam agitation. The resulting solution is separated from the gangue and treated with oxidizing precipitants to throw out hydrated vanadic acid. The precipitants mentioned by the inventor are sodium or potassium chlorate or the gas generated when hydrochloric acid acts on sodium chlorate, or ammonium persulphate. The red precipitate is separated and calcined for the production of  $V_2O_5$ . The liquor remaining after the precipitation can be used again for solution of vanadium, and such use continued until the solution is nearly saturated with other metallic compounds. The latter may then be recovered as by-products. (1,020,224-1,020,312, March 12, 1912.)

#### Alloys.

**An anti-corrosive alloy** suitable for use in the manufacture of tanks, pipes, valves, ropes, pumps and similar mining machinery has been patented by Mr. GASTON JACQUIER, of Belgravia, near Johannesburg, Transvaal, South Africa. The alloy can be used as the sole material of which the aforementioned machines are made, or it can be used as a coating only. The alloy is made of the following substances: Aluminium, 92 per cent; bismuth, 2 per cent; copper, 5 per cent; silicon, 1 per cent; or the composition may be as follows: Aluminium, 91 per cent; bismuth, 2 per cent; copper, 5 per cent; magnesium, 2 per cent. (1,019,963, March 12, 1912.)

**Iron-Nickel-Copper Alloy.**—An alloy containing from 25 to 50 per cent nickel, from 5 to 20 copper, and from 30 to 70 iron, is patented by Mr. G. H. CLAMER, of Philadelphia, Pa. The amount of carbon must not be so high as to cause the copper to separate out in form of nodules; but the strength of the alloy is regulated by the amount of carbon present; "two-tenths of one per cent of carbon is not too much." An alloy containing 65 per cent iron, 25 nickel, 10 copper, and 0.2 carbon has the following properties: "On a test bar  $\frac{1}{2}$  in. in diameter and 2 in. between shoulders, strain per square inch in pounds 96,100; limit of elasticity per square inch in pounds, 51,750; elongation per cent of original length 42; reduction of area per cent of original section 53.7." The alloy may be made directly from appropriate ore (compare our Vol. VIII, p. 527 and 546) or by mixing the ingredients and melting. (1,016,549, Feb. 6, 1912.)

#### Titanium.

Quite a number of patents, relating to the production of titanium alloys and the uses of titanium as purifier in the metallurgy of iron and steel as well as of the non-ferrous metals, have recently been issued to Mr. AUGUSTE J. ROSSI, of Niagara Falls, N. Y. All of them are assigned to the Titanium Alloy Mfg. Co.

**Ferrotitanium.**—To reduce the losses by volatilization,

oxidation, etc., in the manufacture of ferrotitanium, Mr. Rossi now proceeds as follows: Onto the surface of a molten bath of iron in an electric furnace he charges lime  $CaO$  so as to form a complete molten cover, and onto this he charges a mixture of titanic acid and carbon, comminuted or agglomerated in briquets. The quantity of carbon must be sufficient for the reduction of both the titanic acid and the lime. Where the temperature is raised, this reduction occurs according to the formulas  $CaO + C = CaC_2 + CO$  and  $TiO_2 + C = Ti + 2 CO$ . The reduced metallic titanium sinks down and alloys with the iron, while the cover of lime changes into one of calcium carbide, which acts as a reducing agent and protects the metal bath below. Toward the close of the operation an additional covering of carbon may be added to the surface to insure a reducing atmosphere throughout the furnace. (1,019,528, March 5, 1912.)

**Zinc-Titanium, Tin-Titanium, Lead-Titanium.**—Quite the analogous process to the one just described for ferrotitanium, may be employed for the production of zinc-titanium (1,019,527, March 5, 1912), tin-titanium (1,019,530, March 5, 1912), and lead-titanium (1,019,529, March 5, 1912). However, for the production of lead-titanium Mr. Rossi also describes a second different method. He charges into a graphite crucible a quantity of molten lead and adds to it litharge or other lead oxide and also titanic acid and as much aluminium in shots as is required for reduction. By heating the mixture, reduction is brought about according to the equations  $3 PbO_2 + 4 Al = 2 Al_2O_3 + 3 Pb$  and  $3 TiO_2 + 4 Al + Pb = Pb + 2 Al_2O_3 + 3 Ti$ . Carbon may be used instead of aluminium as a reducing agent, but in this case an electric furnace must be employed to attain the required high temperature. (1,020,516, March 19, 1912.)

**Silico-Titanium.**—In cases in which ferrosilicon and ferrotitanium are employed together, a silico-titanium alloy may be directly used instead. An alloy containing 70 per cent silicon and 30 per cent titanium is produced by Mr. Rossi as follows: 150 lb. of silica, 50 lb. titanic acid and 75 lb. carbon are heated together in an electric furnace, to produce the reactions  $SiO_2 + 2C = 2CO + Si$  and  $TiO_2 + 2C = 2CO + Ti$ . Thereby 100 lb. of the desired alloy are produced. If 20 lb. of iron scrap are added to the above mixture, 120 lb. of an alloy containing 16.7 per cent Fe, 58.3 per cent Si, and 25 per cent Ti, are obtained. (1,019,526, March 5, 1912.)

**Aluminium-Titanium.**—To produce an aluminium-titanium alloy from aluminium and titanium oxide alone, Mr. Rossi proceeds as follows: To a bath of molten aluminium he adds a mixture of titanium oxide and solid aluminium in shots. The titanium oxide is reduced by the aluminium, but the heat thereby set free is used up in melting the solid aluminium shots. Such additions of mixtures of titanium oxide and solid aluminium are made from time to time. The process is carried out in an electric furnace, in order to have exact temperature control, the current being switched on or off whenever required. (1,020,517, March 19, 1912.)

**The Use of Titanium in Non-Ferrous Metallurgy.**—The high affinity of titanium for oxygen and nitrogen and the great usefulness of titanium as a deoxidizer and in general as a purifier of metals is well known. The process is in all cases the same. To the bath of molten metal to be purified a little titanium is added, just enough to take care of the undesired elements oxygen, nitrogen, etc., including drosses and slags. In general the quantity of titanium is so chosen that practically all of it acts for purification and therefore passes in the slag, so that the purified metal does not contain more than 1 per cent titanium. The titanium is usually added in form of an alloy, for instance, a zinc-titanium alloy, if zinc is to be purified, or an aluminium-titanium alloy, if aluminium is to be purified, etc. The process is described in detail for the purification of zinc (1,020,512, March 19, 1912), aluminium (1,019,531, March 5, 1912), lead (1,020,514, March 19, 1912), tin (1,020,515, March 19, 1912), and nickel (1,020,513, March 19, 1912).

### Boron.

In connection with the very important paper on boron, presented a few years ago before the American Electrochemical Society by Dr. E. WEINTRAUB of the General Electric Co. of Lynn, Mass. (our Vol. VII, p. 509), several recent patents of Dr. Weintraub are of interest.

**Reduction of Boric Chloride.**—A mixture of a volatile reducible compound of boron, as, for instance, a halide, is mixed with a reducing gas, such as hydrogen, and brought into contact with a thin refractory tube heated electrically to the temperature of reduction. Boron is thereby reduced and deposited on the refractory tube. When the boron layer has reached sufficient thickness, the original tube of refractory material is removed by mechanical means, leaving a tube of pure boron. (The process may also be employed for the reduction of other difficultly reducible metals, such as titanium, in a state of high purity.) The reduction chamber comprises a gas-tight vessel of glass and in its centre a thin-walled heater tube of carbon or graphite prepared either by carbonizing tubes of paper or by turning down carbon or graphite tubes to the desired thickness in the lathe. A mixture of boric chloride and hydrogen gases is then introduced into the vessel, displacing the gas in the vessel, which may conveniently consist of hydrogen. Current is then turned on, bringing about the chemical reaction between boric chloride and hydrogen, whereby boron is deposited upon the surface of the tube and hydrochloric acid gas is formed which is removed. (1,019,394, March 5, 1912.)

**Purification of Boron.**—To purify boron and reduce suboxide of boron (such as obtained, for instance, by treating a mixture of boric anhydride and magnesium, containing boron anhydride in excess, at a temperature of 1300 to 1600° C. or more), the boron material is pressed into sticks or rods which are heated to 1000° C. to render them slightly conductive and are then mounted as electrodes in a high-tension arc furnace. This consists of a gas-tight vessel of glass or copper with two terminal connections in form of water-cooled copper tubes. To the ends of these copper tubes the boron-material sticks are fastened by means of copper clamps. If the electrodes are initially separated by a distance of one-fourth of an inch and are surrounded by hydrogen at a pressure of not more than 5 in. of mercury, the voltage necessary to cause the current to jump the gap and start an arc is from 15,000 to 30,000 volts. Under these conditions the impure boron electrodes need be but slightly conductive. The hydrogen atmosphere keeps the arc concentrated on the extreme ends of the boron sticks. The impure boron sticks progressively heat up and fuse, the boron loses its oxygen or magnesium, as the case may be, and becomes very pure and dense. (1,019,392, March 5, 1912.)

**Manufacture of Boron and Boron-Carbon Alloys.**—Pure fused boron is a fair conductor of electricity and has an enormous negative temperature resistance coefficient. The addition of a small amount of carbon increases the initial conductivity of the boron and lowers its extreme negative temperature resistance coefficient to an extent depending upon the amount of carbon added. For example, a few tenths of a percentage of carbon may vary the resistance tenfold. In certain cases this effect is desirable. In a similar manner the presence of a small amount of carbon modifies the wear-resisting qualities of the boron when used as a bearing or die. Boron containing a small percentage of carbon may be produced as follows: A carbon-filament is heated to incandescence in a mixture of vaporized boron chloride and hydrogen, thereby depositing pure carbon on the surface of the filament. During this process, especially if the temperature is raised considerably, the carbon diffuses through the mass of boron. If a perfectly homogeneous product is desired, the mass is fused down in an arc. As the carbon filament has a very small mass and the deposit of carbon can be made quite thick if desired, the percentage of carbon in the final product may be made practically as small as desired. If it is desired to produce thick rods with a higher percentage of carbon, the carbon is deposited simultaneously

with the boron by adding to the mixture of boron chloride and hydrogen a vaporized carbon compound, such as gasoline or carbon tetrachloride. Boron chloride and gasoline are completely mixable and, therefore, can be mixed in liquid form and vaporized at the desired rate either by dropping into a vessel which is somewhat heated, carrying the vapor off with a stream of hydrogen or by merely passing the hydrogen gas over the liquid mixture. (1,019,569, March 5, 1912.)

Another method is to first produce pure boron by passing a mixture of boron chloride and hydrogen through a high-voltage alternating-current arc maintained between water-cooled copper electrodes. The reduced boron is driven out of the arc by the action of the arc blast, and some of it fused on the ends of the electrodes, and the rest of it is thrown out as a powder on the walls of an arc chamber. The boron in powdered form is mixed with the desired amount of carbon in the form of powdered graphite, or is mixed with powdered silicon, magnesium or aluminum (if such alloys are to be produced), is then compressed into sticks, and is then fused in a high-potential arc operating in hydrogen, using the sticks as electrodes.

According to another process, an excess of boric anhydride is reduced with magnesium at a temperature of at least 1300 degrees C., but preferably higher. The resulting product is a brownish powder containing boron and oxygen, and is probably a suboxide of boron. It is pressed into stick form and is heated to fusion in a vacuum furnace of the Arsem type containing a graphite heater. As it is necessary to run the heater at a temperature of about 2500 deg. C., a small amount of carbon is introduced into the fused boron, as carbon vapor exists at this temperature in the furnace. If it is desired to introduce a larger amount of carbon than is obtainable by this fusion, the desired additional amount can be mixed with the powdered suboxide of boron before introducing it into the furnace.

If it is desired to produce as a final product fused boron containing a small amount of magnesium, the reaction between boric anhydride  $B_2O_3$  and magnesium is carried on under such conditions that boron combined with magnesium is produced, as by using anhydride and magnesium in theoretical amounts and carrying out the reaction at a relatively low temperature, that is, below 300 deg. C. The product is then fused in a vacuum furnace. A very small amount of magnesium remains in the product. (1,019,393, March 5, 1912.)

### Aluminium.

**Aluminium Solder.**—GEZA HARTMANN, of San Francisco, and R. J. BUSCH, of Los Angeles, Cal., have compounded a new alloy which they claim is superior as a solder for aluminium. The ingredients and proportions are as follows: Aluminium, 15.5 per cent; antimony, 7 per cent; bismuth, 9 per cent; vanadium, 0.25 per cent; magnesium, 2.25 per cent; tin, 66 per cent. In preparing the alloy place the vanadium in a covered graphite crucible. When it is melted, add the correct amounts of bismuth, aluminium, antimony and magnesium in the order given and cover with charcoal powder to exclude the air. Stir thoroughly as each metal is added, and when this mixture is molten and mixed add the tin. When all metals are thoroughly melted and mixed, skim and pour into suitable molds. (1,020,757, March 19, 1912.)

### Miscellaneous.

**Brick for Metallurgic Furnaces.**—A brick which shall have for its body-portion a refractory material which will not yield to pressure or lose form at high temperatures, and a surface portion which will likewise resist high temperatures and at the same time offer greater resistance to the chemical action of molten metals, slags, gases, etc., is the invention of W. M. McNIGHT and R. H. YOUNGMAN, of Pittsburgh, Pa. The patent has been assigned to Harbison-Walker Refractories Company, of Pittsburgh.

The chemically refractory surface which is added to the



brick is not less than  $\frac{1}{4}$  in. in thickness and is placed on that surface of the brick which will be exposed in the furnace. The main portion of the brick may be silica or fireclay such as is used in bricks of that nature; and this main body portion may be burned before the application of the refractory facing, or the facing may be applied to the unburned brick. The refractory facing is of chrome ore, burned magnesite, aluminous clays or aluminous products. A suitable binding medium of relatively low fusing point is placed between the body portion and the refractory facing so that in burning the completed brick, the facing will be fused to the main body. In cases

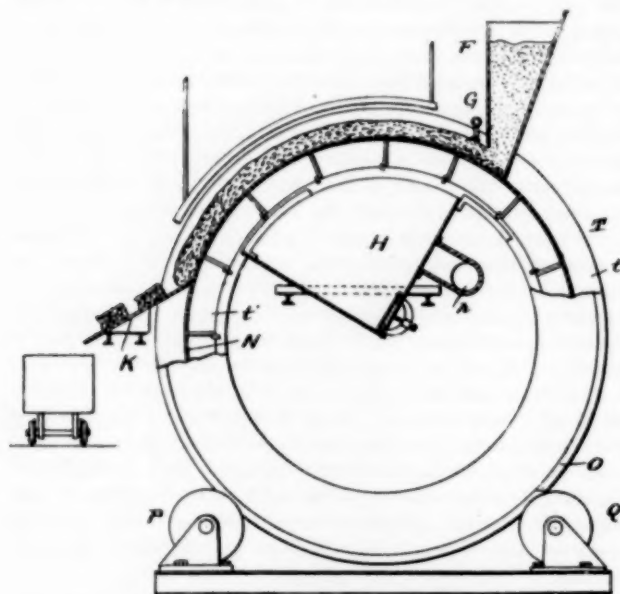


FIG. 6.—ORE SINTERING MACHINE.

where magnesite is used in connection with a silica brick portion, the fusible binder may be omitted, as a fusion can be obtained directly between the magnesite and silica at suitably high temperatures. (1,016,350, Feb. 6, 1912.)

#### Sintered Ore Product.

**The Dwight-Lloyd System** of desulphurizing and sintering fine ore into a mass suitable for charging directly into a blast furnace has been described in our issues for February and March, 1912, pages 87 and 162 respectively. In a patent recently granted to A. S. DWIGHT and R. L. LLOYD, of New York, the drum form of sintering machine is described and the merits of its sinter cake set forth. The sinter produced by the Dwight-Lloyd machines is uniformly porous and hard throughout its entire body in contradistinction to the cakes formed by other processes in which there is variable permeability to gases and increasing hardness from top to bottom of cake.

The drum form of machine for producing this cake is shown in Fig. 6, and differs only in form from the straight-line machines described in one of the articles referred to above. In Fig. 6 the drum has a sectional perforated grate on which the mixture to be sintered is discharged from a feed hopper F. Ignition is effected by a gas burner G, and combustion is continued by suction through the mass into the wind box H. By the time the mixture on any part of the drum has traveled over the arc above the wind box it is formed into a sinter cake, which is discharged as shown at K. (1,020,345, March 12, 1912.)

#### Electric Furnaces.

**Combined Open-Hearth and Electric Furnace for Steel Refining.**—In our last December issue (Vol. IX, p. 659) a patent of Mr. WM. R. WALKER and Mr. JAMES H. GRAY, of the U. S. Steel Corporation, for a combined open-hearth and electric furnace process was mentioned. While that patent related

to the process, another patent has now been granted to the same inventors for the furnace. They first employ the furnace as an open-hearth, the electrodes being removed, and reduce silicon, carbon and phosphorus. When the phosphorus and silicon have been nearly eliminated and the carbon largely reduced, they remove the slag, furnish a new basic slag, introduce the electrodes from the top and operate the furnace as an electric furnace, removing sulphur and oxygen from the bath. The first claim refers to "a combined electric and gas-fired open-hearth furnace for the manufacture of steel, having a hearth for the molten bath, regenerators and flues leading therefrom to the bath, means for venting the gases located between the hearth and the regenerators, and electrodes." (1,018,644, Feb. 27, 1912.)

**Electric Pig Iron Furnace.**—Mr. RICHARD FLEMING, of Westfield, N. J., points out that "the shape and operation of the blast furnace have been adopted after centuries of experience and represent necessities in the reduction of the oxides of iron by carbon which are independent of the particular method of heating employed, whether this method of heating be electrical or by combustion." For electric iron ore reduction he, therefore, adheres as much as possible to the original design of the blast furnace. The "electrical heating must be applied at the point or zone where the maximum development of heat occurs in the ordinary blast furnace so that the thermal reactions may go on in the usual manner. This involves heating at the narrowest part of the boshes." At that point water-cooled electrodes, symmetrically arranged around the furnace circumference, are provided. The iron is reduced and melted and slag is formed and the molten iron and slag drop below the bosh lines into the hearth. The electrodes are so placed that a substantial portion of them is outside the inner surface of the furnace wall. Since they are water-cooled they will build up by the formation of false electrodes or ends from the material reduced in the furnace. Twyers are provided, since the use of a small air blast is convenient in regulating the amount of carbon in the iron produced and to obviate the effects of any excess of carbon due to careless charging. The furnace is stated to be applicable also to the smelting of other metals. (1,020,546, March 19, 1912.)

**Shaft Furnace for Electric Ore Reduction.**—Fig. 7 shows a shaft furnace patented by Mr. ALBERT E. GREENE. A masonry shaft 1 is supported on plates 15 carried by a series of columns

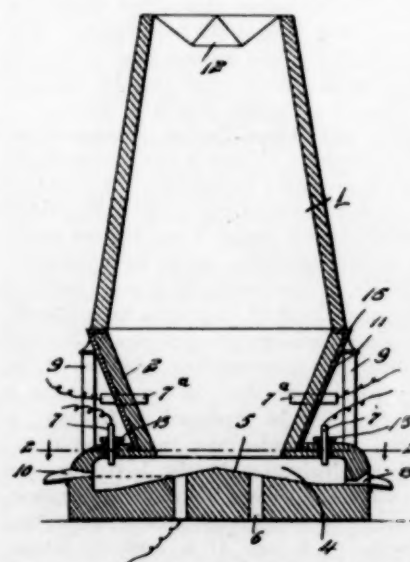


FIG. 7.—ELECTRIC SHAFT FURNACE.

9. Converging downwardly from the bottom of the shaft 1 is a bosh, with water-jacketed walls 2 of refractory material. Directly beneath the bosh is the smelting chamber 4 whose roof extends outwardly as a flange about the lower end of the bosh. In this way free space is provided on the exterior sides of the wall 2 for access to the roof of the smelting chamber. Extending downwardly through the roof are the electrodes F. Embedded in the bottom of the hearth is another annular electrode 6. The metal tap hole is at 8, the slag tap hole at 10. The bottom of the hearth is upwardly inclined toward the center so that the outer peripheral portion of the

hearth forms an annular conduit, the size of which is so proportioned as to determine the intensity of the current carried by the molten metal below the slag. If additional heat is required, it may be supplied through the auxiliary electrodes 7a. (In a modified design also described, these are omitted as well as the bottom electrode 6.) The charge is fed from the top and while it descends it is heated and reduced by the ascending gas. At the lower end of the shaft its passage into the smelting chamber is restricted by the bosh. The charge, resting partly upon the bosh and partly upon the hearth, is held in close proximity to the slag bath, into which the electrodes project, the layer of slag acting as a resistor. The molten metal flows downward through the slag into the hearth. By the construction of the bosh the charge is prevented from falling into the smelting zone and thus displacing the slag bath. The carbon electrodes do not come into contact either with the unreduced charge or with the decarbonized iron. (1,021,187, March 26, 1912.)

**Self-Regulating Induction Furnace.**—In order to make an induction furnace self-regulating, Mr. RICHARD FLEMING of the General Electric Co., Lynn, Mass., makes the primary coil movable, as shown in Fig. 8. The crucible 1 is circular, 2

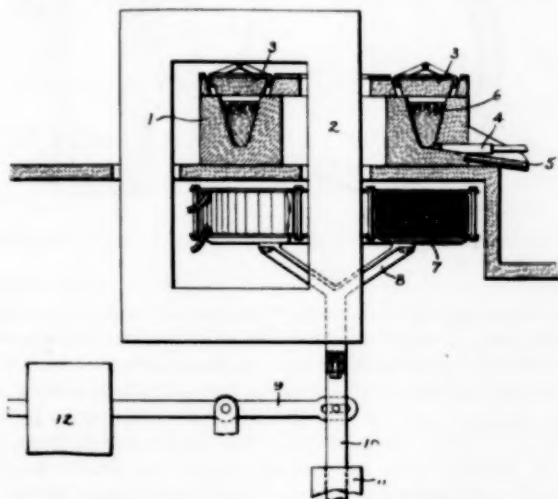


FIG. 8.—SELF-REGULATING INDUCTION FURNACE.

is the magnetic iron core, and 7 is the primary coil, which is so mounted on a frame 8, supported by a lever 9 with a counterweight 12, that it can move toward the furnace 1 or away from it. When the resistance of the charge in the crucible is large, the primary coil will be pressed (by the action of the counterweight 12) against the crucible 1. When the resistance of the charge decreases the increased current will cause the primary coil to be repelled away from the crucible to such a point that the current will decrease to the normal value. (1,020,688, March 19, 1912.)

**Carbon Electrode with Graphite Tip.**—With amorphous carbon electrodes the difficulty is often experienced that the working end cracks and slivers off and pieces of the electrode fall into the charge. To overcome this difficulty without going to the expense of graphitizing the whole electrode, Mr. CHARLES A. HANSEN, of the General Electric Co., Schenectady, N. Y., graphitizes the amorphous carbon electrodes at the tip, or working end only. This is done by placing the electrodes in contact end to end and covering the point of contact with powdered coke. When a current is passed through the electrodes thus in contact, the point of contact is graphitized on account of the high temperature due to the transition resistance. The coke serves to protect the heated carbon from oxidation. The heating is continued in this manner for about 15 minutes. When such electrodes are used and the tip is consumed, the adjacent zone of carbon is progressively graphitized by the heat until the entire electrode is consumed. (1,019,463, March 5, 1912.)

**Water-Jackets for Electrodes.**—A patent of Mr. MARCUS RUTHENBURG, of London, England, refers to the protection of the carbon electrodes against unduly high consumption. It refers especially to furnaces with a stationary casing and a removable hearth, with vertical carbon electrodes suspended from above. If the carbon electrodes are not protected on their sides, they are burnt away by the action of the hot gases rising upwards. Water-jacketing of such electrodes has the disadvantage that the electrodes frequently break and arcs are formed between the broken portions of the electrodes which burn the jackets and allow the cooling liquid to enter the furnace. Mr. Ruthenburg, therefore, provides the electrodes not only with water-jackets, but provides a refractory lining of fire clay or a mixture of fire clay and asbestos between electrode and jacket. (1,018,727, Feb. 27, 1912.)

#### Connection of Carbon Electrodes.

The expense for the electrodes is a large item in electric-furnace operations. It is, therefore, important to utilize the electrodes as completely as possible. This is done by connecting a new electrode to the piece left of a partially consumed electrode so that any waste is avoided. The connection between the old and the new electrode must be strong. If metallic connections are employed, they are liable to fuse and evaporate in the furnace. In a patent of Mr. BERTHOLD REDLICH, of Ratibor, Germany (assigned to the Plania Werke) it is proposed to use connecting pieces of carbon reinforced by embedded metal pieces, as shown in Fig. 9. On the left hand of the diagram various forms of connecting pieces are shown, on the right hand the electrodes in connection with which they are to be used. In the connecting pieces on the left *a* is carbon and *b* metal. As shown in the electrodes on the right, metal bars *f* may be provided in the carbon electrodes *e* themselves to form contact with the metal bars in the connecting pieces. Better connection between the metal bars *b* in the connecting pieces and the metal bars *f* in the electrodes can be obtained by adding to the ends of the metal bars metallic plates *c* and *g* respectively as shown in the two lowest diagrams. These then also act as clamps. The electric transition resistance between the old and the new electrode is thereby materially decreased. (1,018,003, Feb. 20, 1912.)

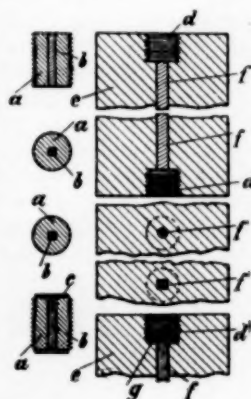


FIG. 9.—CONNECTION OF CARBON ELECTRODES.

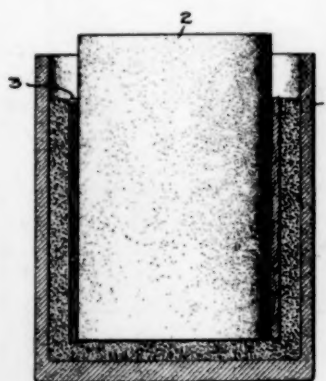


FIG. 10.—MAGNESIA CRUCIBLE.

This firing causes the magnesia to cake together so that re-grinding is necessary. It is ground to the fineness of flour in a tube mill. A mold is then made for the article to be produced, say a crucible. This mold 1 is made of carbon or graphite and a layer of the powdered magnesia is placed on the bottom of 1. A carbon or graphite plug 2 is now placed centrally in the crucible upon this magnesia layer. It is sur-

#### Fused Magnesia Article.

—Mr. GEORGE WEINTRAUB, of the General Electric Company, of Schenectady, N. Y., makes refractory articles of magnesia, alumina, thoria, etc., without the use of a binder, as follows: The magnesium oxide is first heated in an electric furnace to a high temperature in order to let it assume a stable condition.



rounded by a layer 3 of paper which permits the magnesia to shrink when heated. When molding a crucible of  $2\frac{1}{2}$  inches inside diameter, a thickness of paper from  $1/16$  to  $1/8$  in. is suitable. The space between the walls of the mold 1 and the paper-covered core 2 is then filled with magnesia powder and packed to a certain degree by shaking and bumping. The mold is now placed in an electric furnace and heated to about 1500 deg. C. When finished, and the mold is cooled, the walls of the magnesia crucible contract upon the layer of loose paper-carbon, so that cracking is avoided. The finished crucibles are smooth, homogeneous, and strong, may be safely handled and may even be worked on the lathe. Tubes may be made in the same way. (1,022,011, April 2, 1912.)

**Decarburized Silicon—A Resistor Material.**—Commercial cast silicon, such as is available in the open market, is made by reduction of silica with carbon in an electric furnace. It runs relatively high in carbon, the carbon contents being sometimes 3 per cent. Cast resistor sticks made from this commercial silicon, eight inches long and one-quarter of an inch in diameter, have a resistance of about 3 ohms. Mr. JOHN T. H. DEMPSTER, of the General Electric Co., Schenectady, N. Y., has found that by decarburizing silicon completely the electric resistivity may be raised two or three times. The decarburizing process is carried out as follows: Calcium carbonate in the form of lumps, to the extent of 10 per cent by weight of the silicon to be decarburized, is charged into a crucible and then the silicon on top of it. The crucible is then placed into an oil furnace and heated to a temperature of 1400° or 1500° C, so that the silicon melts, while the upper surface of the silicon is changed into a layer of silica. The calcium carbonate then breaks up with the formation of calcium oxide and carbon dioxide. The carbon dioxide bubbles up through the molten silicon and reacts with its carbon content to form carbon monoxide. The calcium oxide also rises to the surface, where it combines, in part at least, with the silica layer and forms a protective slag of calcium silicate. The fused and decarburized silicon has a resistivity of 0.172 ohm per inch cube. (1,019,431, March 5, 1912.)

#### Electrolytic Furnace Processes.

**Sodium Cyanide from Sodium Chloride.**—In a patent, assigned to the Nitrogen Company, Mr. CHARLES E. ACKER, of Ossining, N. Y., proposes a new method for making sodium from molten sodium chloride by electrolysis. A double-com-

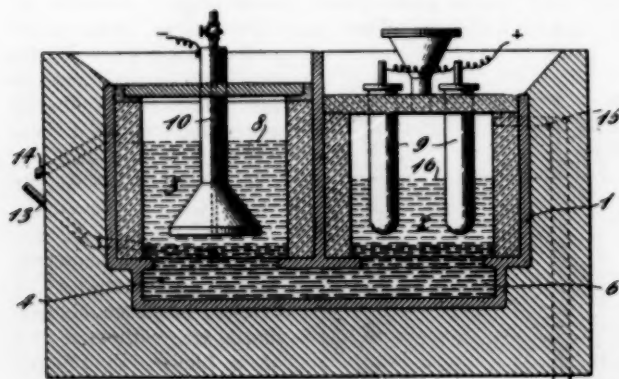


FIG. 11.—SODIUM CYANIDE FROM SODIUM CHLORIDE.

partment cell is used, as shown in Fig. 11. The anode compartment 2, containing the anodes 9 and molten sodium chloride as electrolyte, and the cathode compartment 3 containing the cathode 10 and molten sodium cyanide as electrolyte, are in communication with each other at the bottom through a layer 6 of molten lead, which reaches above the lower end of the dividing wall so that the molten sodium chloride in 2 cannot mix with the molten cyanide in 3. This molten lead layer acts as an intermediate electrode, being cathode in compartment

2 and anode in compartment 3. The results of electrolysis in compartment 2 are evolution of chlorine at the anodes 9 and liberation of metallic sodium at the surface of contact with the molten lead with which the sodium alloys at once. This reaction is essentially the same as in the old Acker process (where caustic soda was produced from the sodium-lead alloy by reaction with steam). Now this molten sodium-lead alloy is circulated by means of a pump and is thus carried over into compartment 3. The reaction in this chamber is that sodium from the molten alloy enters into the molten electrolyte of sodium cyanide, while pure metallic sodium is set free at the cathode 10. Now if this cathode 10 is made hollow and ammonia is blown through the hole so as to react with the metallic sodium "in statu nascendi," then the sodium reacts with the ammonia and with carbon from the cathode, forming directly sodium cyanide, while the hydrogen of the ammonia escapes and carries with it practically no uncombined nitrogen or unused ammonia. In-

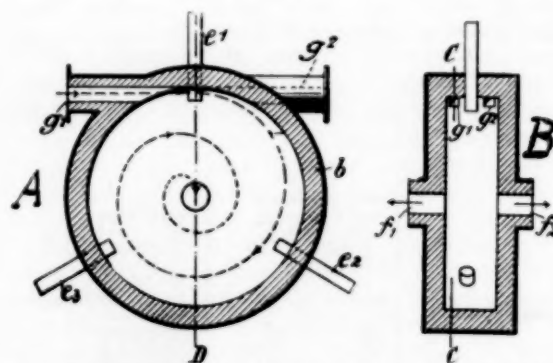


FIG. 12.—FLAME-DISK FURNACE FOR FIXATION OF ATMOSPHERIC NITROGEN.

stead of using up the carbon cathode as source for the carbon in the cyanide, another source of carbon may be provided in the form of finely divided carbon suspended in the electrolyte or as carbon in lump form or in the form of a hydrocarbon gas or oil charged into the cyanide. Instead of ammonia, hydrocarbon bodies containing nitrogen may be charged through the hollow electrode into the electrolyte, such as those obtained from the distillation of "vinasses" of the beet sugar refineries, such as methylamin, di- and trimethylamin, etc. In methylamin both nitrogen and carbon are present in the exact proportion required in the cyanide. The cathode 10 is axially apertured, as stated before, and the lower extended horizontal face of the cathode is provided with a long spiral groove which starts from the openings in the center, so that when a gaseous reagent is introduced through the hollow shank of the cathode, it is forced to follow the course of the spiral groove and thus be made to travel a distance of several feet in contact with the alkali metal, the electrolyte, and the suspended or dissolved material in the electrolyte. This method insures completeness of the reaction (1,018,802, Feb. 27, 1912.)

#### Gas Reactions.

**Flame-Disk Furnace for Fixation of Atmospheric Nitrogen.**—A patent assigned to the Elektrochemische Werke, of Berlin, and granted to Mr. FRITZ ROTHE, of Dessau, Germany, relates to a new method of spreading out an arc. In the fixation of atmospheric nitrogen it is well known that short fat arcs are much less effective than arcs which are drawn out so as to have a large surface. Birkeland and Eyde draw the arc out by magnetic means, Pauling simply relies on the tendency of the air, heated by the arc, to rise and take the arc along and thus draw it out. Both processes have been described many times in this journal. In the method of Rothe one or more flaming arcs are spread out into disklike flame discharge by the enforced movement of the air under treatment alone. The furnace is shown in Fig. 12, in which diagram A is a cross-section through the furnace and B a longitudinal

section on the line  $DD$  of  $A$ . The furnace is of moderate width with respect to its diameter so that the air or other gases under treatment shall be in the form of thin sheets, the movement of the air being in the form of a spiral path. With three-phase currents the three electrodes,  $e_1, e_2, e_3$  are arranged

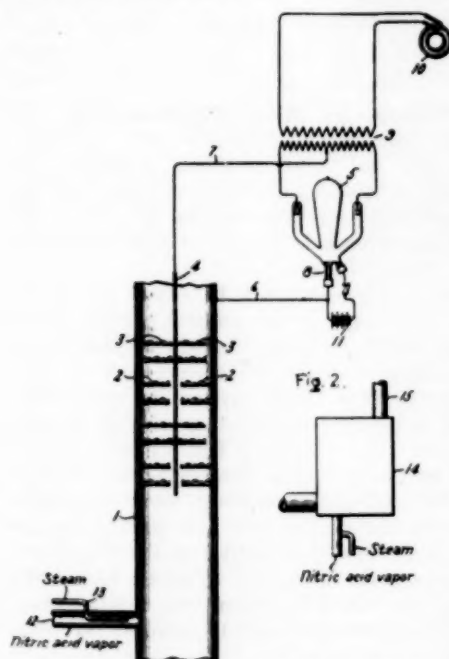


FIG. 13.—PURIFICATION OF SMELTER FUMES.

$g_1$  are shown facing in the same direction. In the former case the air currents will move in opposite directions to each other on opposite sides of the flame zone. In the latter case they will move in the same direction. In any case the air currents move uniformly in spiral paths to the outlet passages  $e_1$  and  $e_2$ , while the arcs are drawn out and re-formed into a disk-like single flame discharge. (1,018,990, Feb. 27, 1912.)

**Purification of Smelter Fumes; Removal of Sulphur Dioxide.**—Solid or liquid particles suspended in smelter fumes may be precipitated by passing the fumes between plates charged to great differences of electric potential, as in the now well-known Cottrell process (our March issue, p. 172), but sulphur dioxide gas is not thus removed. Dr. WILLIS R. WHITNEY, of the General Electric Company, of Schenectady, N. Y., first mixes the smelter fumes with oxidizing agents so as to convert the sulphur dioxide into sulphuric acid, which is precipitated by electrostatic actions. In Fig. 131 is the flue through which the smelter fumes are passed. 2 and 3 are two sets of electrodes charged to opposite direct-current potentials, in form of wire mesh covered with asbestos. Alternating current from the alternator 10 is transformed to high-potential alternating current in the transformer 9 and then converted into direct current by means of the mercury vapor rectifier 5 (the battery 11 serving

to maintain an exciting side branch arc in the rectifier). This direct current is used to charge the sets of electrodes 2 and 3. Before the smelter fumes are passed in a zig-zag path between these sets of electrodes, they are mixed with steam and nitric acid vapors (or with nitric oxide vapors and spray of water) introduced through the pipes 12 and 13, by means of the well known "lead-chamber process" reaction the sulphur dioxide is charged into sulphuric acid and other liquid or solid products such as nitrosyl, sulphuric acid and the like. These liquids or solid products are deposited or precipitated when passing between the high-tension poles. As indicated in diagram II it may be desirable to mix the nitric acid or nitric oxide fumes and aqueous vapors with the flue gases in a reaction chamber 14 to get a more thorough mixture and to allow the reaction to complete itself before the gases are conducted by pipe 15 to the electric precipitating device. Any surplus watery vapor containing dissolved acid is removed by condensation in any suitable manner. (1,022,012, April 2, 1912.)

**Electrical Purification of Gases.**—The application of a high-potential electric discharge for the removal of noxious substances from blast-furnace gases was described in our issue for March, 1912, page 172. This process, which is the invention of Dr. FREDERICK G. COTTRELL, of Berkeley, Cal., has been applied also to the purification of sulphurous gases prior to the manufacture of sulphuric acid. Gases generated by the burning of the commercial forms of sulphur or sulphide ores contain impurities such as selenium, tellurium, arsenic, etc., which destroy the activity of the platinum catalyzer used in the contact process. Various means have been adopted to remove these substances by filtration, agitation with water or steam, etc. Dr. Cottrell proposes, however, to remove them by causing them to collect on particles of mist, produced artificially, and then to remove this mist by an electric discharge. This process of forming a mist may be repeated several times successively, and the purification thereby made perfect. The inventor prefers to form the mist of sulphur trioxide and water according to the following description, in which reference is made to Fig. 14, which is given below.

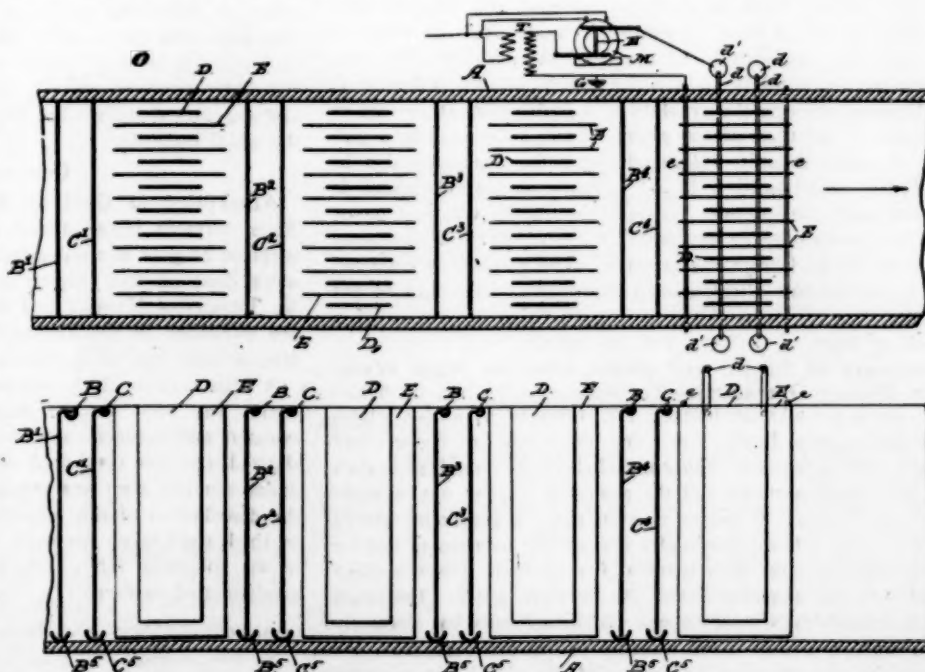


FIG. 14.—ELECTRICAL PURIFICATION OF GASES.

The figure represents a flue in horizontal and vertical longitudinal cross-section, in which the gases flow to the contact chambers in the direction of the arrow. Within the flue are screens  $B^1$ ,  $B^2$ ,  $B^3$ ,  $B^4$ , etc. Above the screens is a trough  $B$  from which water or weak sulphuric acid flows down over the



screen, the excess fluid being removed by troughs  $B^3$  at the bottom. The water thus trickling down over the screen gives off aqueous vapor.

Following each of the water-bearing screens is a second screen  $C^1$ ,  $C^2$ ,  $C^3$ . Each of these screens is supplied with fuming sulphuric acid from a trough  $C$  above, acid in trickling down over the screen gives off  $SO_3$ . The excess acid is received and removed by a trough  $C^3$ .

Within the flue, and following the fuming acid-bearing screens, are mounted the electrodes  $D$  and  $E$ , one set being of opposite polarity to that of the other. These receive their electric charges from the high-potential side of the step-up transformer  $T$  through the intermittently contacting hub  $H$  driven by the synchronous motor  $M$  in such a manner as to make contact at or near the peak of the voltage wave of the high-potential winding of the transformer  $T$ , as more fully set forth in the inventor's United States patent No. 859,729, Aug. 11, 1908. These electrodes  $D$  and  $E$ , by their discharges, precipitate the mist which is formed as follows: By bringing the gases in contact with the screen  $B^3$  aqueous vapor is supplied to them, and on further contact with the screen  $C^3$  sulphur trioxide is added. The gaseous water and acid combine with each other to form a mist of particles of sulphuric acid, and this mist is then precipitated in the chamber provided for the purpose, carrying with it particles of impurities which are undesirable in the acid-making process. This manner of purification is repeated as many times as desired in the succeeding chambers of the flue. (1,016,476, Feb. 6, 1912.)

#### Electroplating.

**Zinc Platings.**—Mr. A. A. LEMÊTRE, of Paris, France, uses for zinc plating a cold solution (not over 30 deg. C.) of 12 kg zinc sulphate, 3 kg ammonium chloride, 2 kg sodium sulphate, 1 kg sulphuric acid in 100 liters of water. Bisulphate of soda may be employed to replace either in whole or in part the sodium sulphate or sulphuric acid, since the latter materials are in time formed in the bath. (1,017,981, Feb. 20, 1912.)

**"Leading" Molds.**—In preparing an electrotype, a mold or case is usually made in a plastic material and covered with graphite or "black lead" to render it conductive. In order to increase the conductivity of the coat and overcome the tendency in the graphite to produce pin holes, Mr. FRANCIS J. McELHON subjects the graphite to a preliminary treatment as follows: A solution of 200 grains of pyrogallie acid in a gallon of water (tannic, gallo-tannic or gallic acid may also be used) is mixed with 8 lb. of graphite and the mixture is stirred until the graphite becomes thoroughly wet and pasty. He then pours in large quantities of water and stirs thoroughly to wash the acid from the graphite. The graphite is collected by decanting and filtration and thoroughly dried and is put on the face of the mold in a dry condition by means of a brush or blast. (1,018,332, Feb. 20, 1912.)

**Recovery of Copper and Nickel from the Wash Water from Plating Operations.**—To make nickel films or flakes for use in his alkaline battery, Mr. THOMAS A. EDISON plates alternately exceedingly fine films or layers of copper and nickel. The composite copper-nickel sheet thus obtained is then cut into small portions and the copper is leached out to leave the nickel flakes. In this process the sheet is alternately placed into a nickel salt solution and a copper salt solution to receive a coating, but after each removal from a bath, it is necessary to remove the adhering liquid film by wash water. The wash water containing soluble copper and nickel salts has formerly been wasted, but now the metallic values are recovered, the copper by concentration on iron, and the nickel by precipitation by means of sodium hydroxide or sodium carbonate. (1,016,875, Feb. 6, 1912.)

**Electroplating Apparatus.**—Mr. T. R. CANNING of Birmingham, England, patents details of an electroplating apparatus for dealing with small quantities of work at one time. The articles are placed in a perforated earthenware receptacle which is revolved in the plating bath by means of an inclined

spindle rotating in the bearing of a bracket fixed to the wall of the vat. (1,020,262, March 12, 1912.)

### Synopsis of Metallurgical and Chemical Literature.

#### Zinc and Lead.

**The Horwood Process for Mixed Sulphides.**—For the separation of galena from blende by flotation, Mr. E. J. HORWOOD proposes to give the mixed sulphides a sulphatizing roast whereby the lead is rendered inactive in flotation and the blende remains unaffected. He describes his process in the *Proceedings of the Australasian Institute of Mining Engineers* (Melbourne), New Series, No. 2.

By roasting blende and galena which have been previously ground sufficiently fine to separate the mineral particles from each other and from the gangue, the lead will be sulphatized and its floatability destroyed if the temperature does not exceed 300 to 400 deg. C. The blende will not be appreciably affected, and it can be separated by flotation with an oil-acid mixture by any of the usual methods. The degree to which sulphatization must be carried can be determined only by experiment for each ore; and once determined, there is no difficulty in obtaining the desired results. The method is applicable to raw ore, or to the mixed minerals obtained by previous flotation or concentration on tables. If pyrites be present in addition to galena and blende it is found that sulphatization of the galena will not proceed until the pyrites has been oxidized.

The results of tests given by the author show recoveries of zinc in zinc concentrates ranging from 80.8 to 95.6 per cent; and of lead in lead concentrates from 81.3 to 91.3 per cent. The concentrates are quite free from contaminating metals which should have been separated. The author states that it is possible to conduct the operation of roasting in such a manner as to determine the recovery of the major part of the silver in either the galena or blende, although he is not certain just what the contributing causes are. Comparatively little work has been on copper-zinc ores. The author states that the leady residues present no difficulty in ordinary smelting, and suggests that they can be briquetted or sintered in any of the usual methods.

#### Gold and Silver.

**Absorption of Gold by Amalgamated Copper Plates.**—Such different ideas prevail regarding the possibility of absorption of gold in amalgamated copper plates that the definite work done on this subject by Prof. G. H. STANLEY and Mr. M. THORNTON MURRAY will be welcomed. Their conclusions are published in the December, 1911, *Journal of the Chem. Met. & Min. Soc. of S. Africa*.

A plate 0.14 in. thick, which had been in service for twelve years, was used for the investigation. The plate had been sweated and scraped, but not scaled. One portion on assay showed 1.69 per cent gold and 1.31 per cent mercury. The under surface also was amalgamated. In order to ascertain the distribution of this quantity of gold, successive layers 0.02 in. thick were taken for assay. The results obtained are shown in the following table. Layer No. 1 is the sample from the amalgamated surface:

Layer No.	Gold %	Mercury %	Lead %	Ratio of Gold to Mercury
1	10.48	9.39	0.085	1.12
2	.0166	present in all cases but in amounts too small for determination	.084	?
3	.00505		.080	...
4	.0084		.053	...
5	.0041		.089	...
6	.0145		.089	...
7	.0018	1.89	.104	.00105

It will be seen that over 99 per cent of the gold was contained in the first layer of .02 in. thick, the remainder being distributed irregularly throughout the plate. It is unlikely that any gold originally in the plate would be present in such

quantity or in such uneven distribution. The lead is probably an original constituent, and being liable to segregation, its uneven distribution is not remarkable. A slight but undoubted concentration of this element is shown in the lower half of the plate, which would seem to support the idea of actual filtration through it.

Cross-sections of the plate examined microscopically showed plainly a gray surface scale of amalgam lying on the corroded surface of the plate. Many circular or elliptical spots, bluish gray in color, and some empty pores or blow holes also appeared. Some of the spots on incomplete polishing showed smears of mercury. The section was then exposed to heat to volatilize the mercury and again examined. The former scale of amalgam on the edge of the plate now appeared as gold, and some of the depressions seemed coated with a film of yellow substance which was in all probability gold. Microscope examination of an unused plate showed similar structure, but no evidence of the presence of gold.

The explanation of the so-called absorption of gold seems to lie in the fact that the copper plates used are more or less porous, and contain minute blow holes, some of which at least communicate with one another. Through these passages the mercury has percolated, carrying gold in solution or suspension till the plate has become saturated. The whole examination supports the view that not enough gold is absorbed to influence percentage recovery. It is quite possible, though, for a hard scale to form which will be very rich in gold and which can be removed by scaling.

The authors also investigated gold absorption in iron retorts and amalgam pans, finding appreciable absorption in the inner layers. In these cases the gold seems to fill crevices and cavities formed when the graphite is burned out of the iron. The suggestion is made that perhaps special grades of iron should be used for retorts and amalgam pans.

**Pebble Loads in a Tube Mill.**—In the *Journal of the Chem. Met. & Min. Soc. of South Africa* for January, 1912, Mr. R. W. DOWLING gives the following valuable data on pebble loads of different depths in a tube mill 22 ft. long and 5 ft. internal diameter:

Depth of Pebble Load	Cubic Feet of Pebbles in Load	Weight in Tons of Pebble Load (105 lb. per cu. ft.)	Relative Volume and Weight of Pebble Load as percentage of total of mill
12 in. above axis of mill	323.0	16.96	74.8
11 " " " " "	314.4	16.51	72.8
10 " " " " "	306.1	16.07	70.9
9 " " " " "	297.3	15.61	68.8
8 " " " " "	288.3	15.14	66.7
7 " " " " "	279.8	14.69	64.8
6 " " " " "	270.6	14.21	62.6
5 " " " " "	261.4	13.72	60.5
4 " " " " "	252.7	13.27	58.5
3 " " " " "	243.5	12.78	56.4
2 " " " " "	234.1	12.29	54.2
1 " " " " "	225.4	11.83	52.2
Level with axis of mill	216.0	11.34	50.0
1 in. below axis of mill	206.6	10.85	47.8
2 " " " " "	197.9	10.39	45.8
3 " " " " "	188.5	9.90	43.6
4 " " " " "	179.3	9.41	41.5
5 " " " " "	170.6	8.96	39.5
6 " " " " "	161.4	8.47	37.4
7 " " " " "	152.2	7.99	35.2
8 " " " " "	143.7	7.54	33.3
9 " " " " "	134.7	7.07	31.2
10 " " " " "	125.9	6.61	29.1
11 " " " " "	117.6	6.17	27.2
12 " " " " "	109.0	5.72	25.2

**Measuring Small Quantities of Low Pressure Air.**—It is frequently desirable to measure the quantity of air used in metallurgical operations, as in air agitation. In order to accomplish this easily, and without resort to expensive apparatus, Mr. G. S. WEYMOUTH, of the Great Fingall Mine, has designed the apparatus shown in Fig. 1. The original article appears in the *Monthly Journal of the Chamber of Mines of Western Australia*, January, 1912.

The method consists in substituting temporarily an equal flow of air under conditions which allow of easy measurement. The only disadvantage is that the flow of air must be diverted from the point of application for half a minute, while the meas-

urement is being made. In the figure *a* is a valve regulating the air to the required pressure; *b* is a mercury gauge; *c* and *d* are stop-cocks; *e* the apparatus under test; *f* a small tin receiver connected by rubber hose to *d*; *g* is a round orifice in a tin plate for air outlet, and *h* is a water gauge with a range of about 12 in. to allow for occasional rushes of air while manipulating the cock *d*.

A low-pressure supply being required at *e*, say, 5 lb. per square foot, and the cock *c* being open and *d* closed, the regulating valve *a* is opened until the gauge *b* indicates the required pressure. The valve *a* should not be touched again during the test. The height of mercury on *b* is marked; and to measure the quantity of air flowing at this instant, the cock *d* is opened and *c* closed; *d* is then gradually closed until the gauge *b* reads the same as before. In this way the total substituted resistance to the free flow of air is equal to that of the apparatus being tested, the pipe *a* to *i* in both cases acting as an intermediate receiver with constant in and out-flow as provided by the gauges. The height of the water gauge is now taken, and the area of the outlet orifice noted; the cock *c* is opened and *d* closed, the gauge *b* reading the same as before. This is a check on the constancy of flow during the testing period. The velocity through the orifice *g* is that due to a

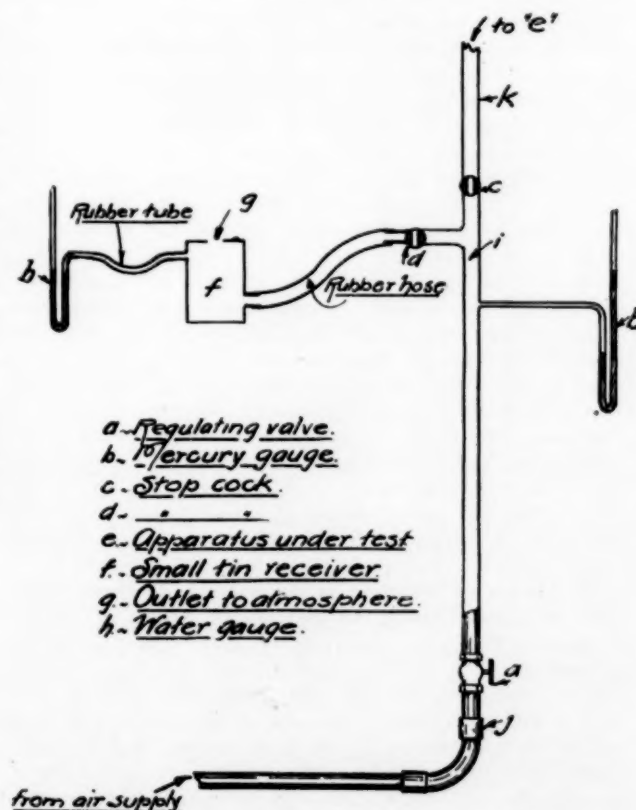


FIG. 1.—MEASURING SMALL QUANTITIES OF AIR.

head of air equivalent to the pressure on the water gauge, and is  $\sqrt{2gh}$  = feet per second, *h* being the height of the motive column (head) in feet. Reducing to inches of water, and simplifying, this becomes  $\sqrt{\text{in. water} \times 66.1}$  = feet per second. The coefficient of flow for such an orifice being 0.64 owing to the contraction of the flow near the edges, the actual mean velocity over the full size of the orifice becomes  $\sqrt{\text{in. water} \times 42.3}$  = feet per second.

In the author's experiments the effective velocities for an orifice of 1 in. sq. area, at pressures up to 4 in. water gauge, were tabulated, with the corresponding discharges of cubic feet of free air per minute. All subsequent readings for different sizes of orifice were simply referred to this table. Removable



screwed caps were used on the receiver, with orifices of 0.125, 0.25 and 0.5 sq. in. area, these being simple fractions of 1 sq. in.

These different orifice sizes were used to keep the water gauge readings within reasonable limits, and covered all measurements up to 7 cu. ft. per minute with  $\frac{3}{8}$ -in. pipe fittings. Pipe sizes do not come into the calculations, provided they are large enough to carry the quantity of air. The receiver  $f$  need be only of sufficient size to reduce the kinetic action of the air to a negligible quantity and give a true reading on the water gauge.

In the author's actual experiments the receiver  $f$  was a tin of about 1 qt. capacity. For air lifts consuming about 50 cu. ft. per minute a 5 gal. can was used, with orifices of 0.5, 1, 2 and 4 sq. in. area. The pipe fittings in this case were 1 in. No difficulty was found in measuring quantities between 0.5 and 60 cu. ft. per minute. By substituting a high-pressure gauge at  $b$  readings can be taken at any pressure. A little experience soon gives the proper size of orifice to use.

#### Tin.

**Tin Concentration in Bolivia.**—In the *Australian Mining Standard* for Feb. 8, 15 and 22, 1912, Mr. O. GORE ADAMS gives detailed account of tin mining and dressing operations in several Bolivian mines and mills.

At the Llallagua mill the ore is treated in jigs and on tables in the usual manner, with intervening stage crushing. The final recovery is made on stationary canvas tables. Complete costs and details of operation are given, as follows: During one month the mill treated 3338 tons of ore of an average grade of 7.15 per cent tin. The concentrate contained 65.1 per cent tin. The recovery was 96.08 per cent. (These costs are calculated from "Bolivianos" and "pence" given by the author.)

The detailed cost of mining and milling is given as follows, per ton of ore treated: Exploitation, \$6.38; development, \$3.18; milling, \$3.35; total cost to produce concentrate in store at the property, \$14.20 per ton of ore treated. To this must be added the cost of freighting and exportation, which amount to \$2.45 and \$1.95 respectively, per ton of ore treated. The costs calculated per ton of concentrate produced are, exploitation, \$58.25; development, \$29.55; milling, \$31; total cost to produce concentrate in store at the property, \$132.25. Add to this the cost of freight, \$23, and duties, \$18.75. The total cost of marketing the concentrate, including every expense incurred, comes to \$190 per ton of concentrate.

The system of treatment at the Socavon de Oruro mill is quite complicated owing to the complex nature of the ore. It contains tin, lead, copper, silver, gold, antimony, arsenic, sulphur, etc. An effort is made to save the first five. The ore is crushed dry in ball mills having screens of diagonal slots 1 millimeter wide. The ore is then roasted in hand-rabbed reverberatories, having three hearths in line, each 4 inches below the preceding. There is sufficient fuel in the ore to maintain combustion. About 4 per cent of salt is added to the charge on the last hearth, and the discharged mixture is sent to the cooling floor where it is moistened. It is then leached with water for 24 hours, to dissolve the soluble copper and silver which are later precipitated on scrap iron. The precipitate contains about 50 per cent copper and 250 oz. silver per ton. The ore is then subjected to the leaching action of a solution of  $\text{Na}_2\text{S}_2\text{O}_3$ , 0.5 per cent strength, for two or three days.

The resulting solution then contains from 300 to 600 grams silver per litre, and is precipitated by calcium sulphide. The precipitate is filtered, dried, roasted and shipped to Europe. It assays 35 per cent silver, 23 per cent lead, 2 per cent copper and 4 oz gold per ton. The residue from this leach is classified and concentrated on jigs, tables and buddles. Natural deposits of salt, lime and sulphur are found in the vicinity, so that the cost of these minerals is not high.

### Pumping by Compressed Air.

#### Applications of Compressed Air in Chemical and Metallurgical Engineering Practice.

The use of compressed air for the transfer and agitation of liquids has become of such importance in modern chemical and metallurgical engineering practice that a recent lecture by Mr. HERBERT T. ABRAMS on this subject should prove exceedingly interesting. Mr. Abrams is connected as engineer with the Ingersoll-Rand Company and his lecture was delivered last year before the Department of Mechanical Engineering of Columbia University. It is published in the April, 1912, issue of the *School of Mines Quarterly*. In view of its great interest to our readers we reproduce the lecture here almost in full.

The field in which compressed air can be used for lifting and forcing water is divided by Mr. Abrams into four distinct methods:

1. Pumps of the ordinary direct-acting type driven by compressed air;
2. Pneumatic displacement pumps;
3. The "return-air" system;
4. The "air-lift" system.

#### Direct Acting Pumps.

Mr. Abrams passes briefly over the use of air in place of steam for operating ordinary mechanical pumps. High economy must not be expected in a combination of this kind for the reason that pumps of this type, of themselves, are wasteful of power, and, generally speaking, no consideration is given as to whether they are to be run by steam or by air, no attention is paid to proper ratio of cylinders, and seldom is there any attempt to re-heat the air either before using it in a simplex or duplex pump, or between stages in a compound pump.

"Compressed air should be used in a great many instances where steam is now being wasted, but we are so inclined to listen to talk about 'compressed air efficiencies,' meaning always 'compressed air losses,' that we frequently lose sight of the more important final analysis, which is to define whether a saving in fuel is an actual credit or whether such apparent balance is not over-balanced in the item of extra labor or upkeep or general utility."

As compressed air is found driving steam pumps in mines, quarries, and wherever there is an available supply of air, Mr. Abrams briefly gives the simple rules used for proportioning pumps and the volume and pressure of air needed to run them.

The simplest way to find the quantity of free air and the pressure required is first to determine at what speed and under what air pressures the pump is to be run, and calculate the cubic feet displaced per minute at the pressure necessary to do the work. This may readily be converted into terms of free air at sea level or the greater quantity at any altitude. To this must be added a percentage, say 10 per cent, for the loss due to leakage.

With a given air pressure and head of water, the diameter of the air cylinder may be found by the rule: Determine the pounds pressure of resistance by taking one-half the elevation in feet, as representing the equivalent pressure in pounds, add one-third excess for pumps over 7-in. stroke. Divide this result by the pounds pressure of air at the pump, and the result will be the proper ratio.

Knowing the dimensions of the air cylinder and pressure, the free air requirements can be calculated by means of the simple formula,

$$V = 1.1 \frac{ASP}{144 Pa}$$

where

$V$  = volume of free air per cubic feet per minute,

$S$  = Piston speed of pump in feet per minute,

$P$  = absolute air pressure at pump.

$A$  = area of air cylinder.

$P_a$  = atmospheric pressure at any elevation.

**Problem.**—Pump assumed over 7-in. stroke; head, 360 ft.; air pressure, 60 lb.

To find area of air cylinder, add one-third to the head (360 plus  $\frac{1}{3}$  = 480 ft.). Take one-half of this head as the equivalent pressure (240 lb.). Dividing 240 lb. by 60 lb. pressure gives a ratio of 4, or, in other words, the air cylinder should have four times the area of the water cylinder.

Having decided on a pump to handle 50 gal. of water per minute at a piston speed of 100 ft. as the proper size, we find,

at the bottom. Air pressure entering at the top is alternately delivered to the chambers, expelling the water in them through the discharge valves and pipe. When a tank is nearly empty the contained air is exhausted through a port in the valve mechanism, while water replaces it through the foot valve as soon as the air pressure is relieved, the alternate discharge being entirely automatic.

The proper field of this device is that calling for the pumping of water at some distance from the source of power, where there is an unobstructed supply and a limited lift. Valves in the power house on the air line to the pump, or to as many of them as may be needed to pump from a number of sources, control the operation, and pumping must continue as long as air is supplied.

The advantages are that these pumps can be easily installed, and where an existing supply of compressed air is available the cost of equipment is low. There is no pump house to build and maintain at the water supply; the operation is controlled in the engine room; there are no piston or plungers to repair and renew, and the wear on valves is less than in any ordinary direct-acting mechanical pump. Neither lubrication nor packing is required and the attention

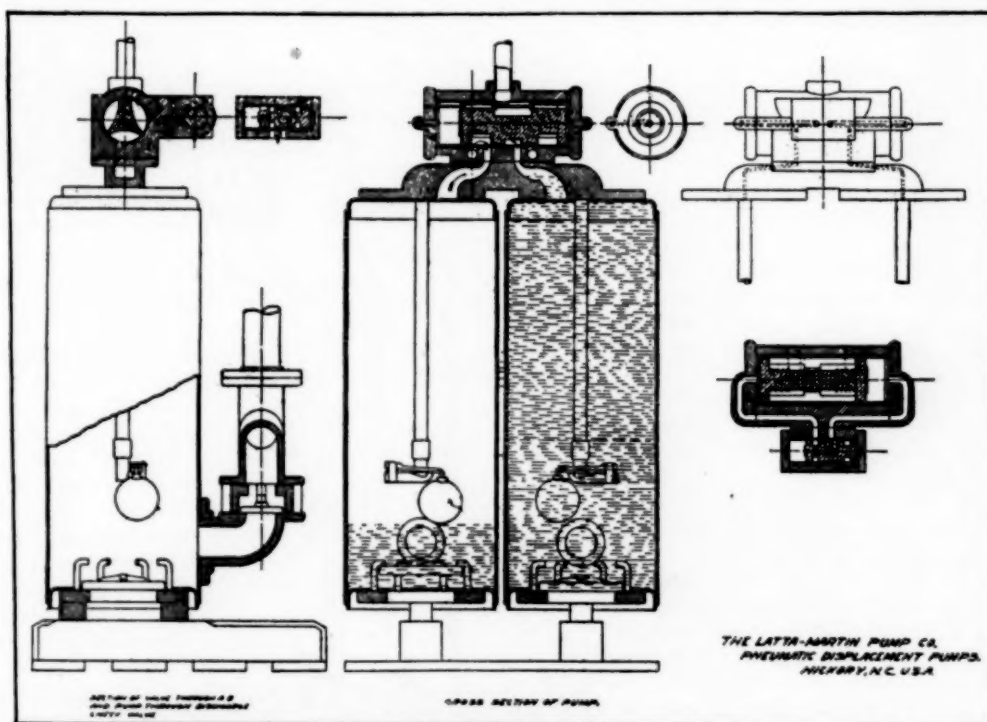


FIG. 1.—COMPRESSED-AIR DISPLACEMENT PUMP.

either by calculation or by manufacturers' tables, that the water end is represented by  $3\frac{1}{2} \times 7$ -in. cylinder. Our ratio having been established at 4 to 1, the diameter of the air cylinder will be 7 in. and its area 38.5 sq. in.

Now, substituting in our formula the values so far obtained, we have,

$$F = 1.1 \frac{38.5 \times 100 \times 75}{144 \times 15} = 148 \text{ cu. ft. free air per minute,}$$

showing a total efficiency referred to I.H.P. in steam cylinder of compressor of approximately 19 per cent. If the air is reheated to 300 deg., the requirement will be reduced about one-third

#### Pneumatic Displacement Pumps.

Fig. 1 is a sectional view of a compressed air displacement pump. This pump uses air non-expansively, but owing to the fact that air comes in direct contact with the water pumped, without the intervention of moving parts, such as pistons or plungers, the work under moderate heads, up to 100 ft., is done in a satisfactory and efficient way.

The pump consists of one or two cylinders with inlet and discharge valves for water, and a valve mechanism controlled by floats or other means for admitting compressed air directly to the surface of the water within the tanks, and for exhausting the air after the water has been expelled. The tanks must be submerged in a suitable sump or cistern properly protected, of sufficient depth to insure that the pump tanks will fill properly by gravity. It will be seen that the pump is really a simple apparatus. Water enters through the large inlet valves

charges are reduced to a minimum. Its working is not affected by muddy or gritty water.

These facts adapt the pump for dye works, bleacheries, pulp mills, and for handling solutions. It may be used to take water from a cistern or reservoir filled by the air-lift from wells, or placed in a remote sump in a mine or quarry, it can be employed to deliver water to the main pumps.

Since the pump operates by the direct displacement of a volume of liquid by a volume of air under suitable pressure, it follows that simple rules can be given for arriving at the volume of air and pressure needed to do the work.

Reduce the quantity of water in gallons per minute to cubic feet. Multiply the total head (static head plus water-pipe friction) by 0.434; this gives the working air pressure at the pump. Next find the ratio of air pressure to atmosphere, which multiplied by the cubic feet of water per minute gives the cubic feet of free air per minute needed at the pump to displace this volume of water.

Knowing the volume of free air required, 5 to 10 per cent should be added for leakage and clearance according to the special conditions.

This is net, actual free air and not piston displacement of compressor; therefore, in figuring on a compressor to do the work, volumetric efficiency must be taken into consideration, following the general practice in such cases, according to the pressure, size and type.

**Problem.**—Source of supply, a river; distance from power house, 1000 ft.; lift, 60 ft.; diameter discharge main, 4 in.; quantity of water required per minute, 150 gal.

$$150 \text{ gal} = 150 \div 7.5 = 20 \text{ cu. ft.}$$



Static head ..... 60 ft.  
Friction head 150 gal. per min. in 4-in. pipe 1000 ft. long 16 ft.

Total head ..... 76 ft.

$$76 \times 0.434 = 33 \text{ lb.}$$

$$33 \div 15$$

$$\text{Ratio } r = \frac{33}{15} = 3.2$$

Free air =  $20 \times 3.2 = 64$  cu. ft. per minute.

Allow 10 per cent for leakage and clearance = 70 cu. ft. net.

If the compressor selected will show a volumetric efficiency of 80 per cent, the piston displacement required will be  $70 \div 0.80 = 88$  cu. ft. per minute.

$$\text{Theoretical horsepower} = \frac{150 \times 8.33 \times 76}{33,000} = 2.88.$$

I.H.P. in steam cylinder of compressor = 8.5.

Total efficiency =  $2.88 \div 8.5 = 33$  per cent.

### Return Air System.

The elevation or transfer of water and other fluids or semi-fluids by direct displacement with compressed air is so natural and self-evident a proposition as to need almost no suggesting. It appeals at once merely on the ground of convenience and simplicity. But the principle as ordinarily applied has been open to the objection that it was not economical.

One characteristic of the ordinary, plain, displacement pump is waste of power entailed by direct release of the displacing air after the fluid is ejected from the pump tank. This air, after doing its work, is still at practically full pressure, therefore having all its potential energy of expansion. Its direct exhaust into atmosphere after displacement is the throwing away of this expansive power without any useful effect.

If air pipes are carried back from the pump to the compressor so as to add the residual pressure after displacement to the reverse side of the compressor piston, where it will help in compressing air into the pump tank, we have a return-air, expansive displacement pump, operating at good economy.

Mr. Abrams emphasizes, at this point, the fact that both the plain displacement pump and the "return air" system have the following advantages which are unique in that, while other pumping systems have some of them, no other systems combine them all to such remarkable degree:

1. Simple in construction, installation and management.
2. Wholly automatic in operation.
3. Under instant and complete control from the compressor room, however distant.
4. No delicate mechanism exposed to corrosive or abrasive action.
5. No oil or other lubricant required by the pump.
6. Not affected by any excess submergence except that operation is improved under a hydraulic head.
7. Applicable to the pumping of all fluids or semi-fluids, as well as mud, sand, or any debris which will pass the valves.

Where water is to be pumped, the field of the pneumatic displacement pump and the return-air system is that in which large volumes are to be handled from a generous source of supply, where complete submergence can be secured, such as in a river, lake, mine or quarry sump, large spring or an excavated well. This, at once, opens to them the supplying of water for small municipalities, shops, mills, factories, etc.

The fact that these systems will handle anything sufficiently fluid to pass their valves adapts them also to the handling of solutions in salt works and bleacheries; the moving of semi-fluids, as in pulp mills; the handling of cement, slurry and marl; the pumping of glass sand for glass factories; elevating salt solutions in salt works, and the pumping of sewage.

Under normal conditions it is safe to say that the return-air system will show an average efficiency of 50 to 55 per cent, this efficiency being the ratio of horse-power of water lifted to the indicated horse-power in the steam cylinder of the air compressor,

including all losses. It is easy to estimate from these figures just what they mean in terms of fuel saving.

Yet the question of fuel economy is but one argument in favor of the return-air system. Another argument is that the compressed air system may be operated with a far less boiler horse-power, with a corresponding reduction in first cost of boiler plant, interest, maintenance, repairs and firing cost. Where a plant is crippled by a shortage of boilers, the substitution of the return-air system for a less economical pumping system will relieve the embarrassment.

Continuing still further the argument for this system, Mr.

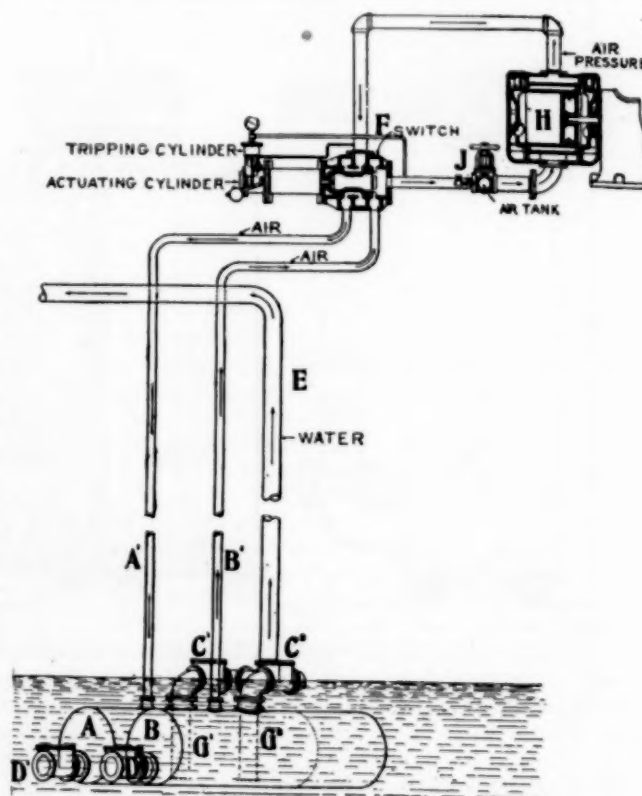


FIG. 2.—RETURN-AIR DISPLACEMENT SYSTEM.

Abrams notes that the tank equipment needs absolutely no care. The operation being entirely under control from the engine room, the engineer can at any time start, stop or vary the pumping. There is no possibility of drowning out the system. In fact, it operates with proportionately less power as the height or head of water above the tanks increases. It cannot become choked by such silt or dirt as may enter a mine sump.

The return-air system cannot be classed as a pump, or as machinery of the kind regularly catalogued and listed. It is a complete system in itself, consisting of an air compressor, a receiver, a reversing switch, two air lines, each leading from the compressor through the switch to one pump tank, and two pump tanks, all in a closed circuit, in which, by a regular cycle of operations, one air volume is compressed, expanded, recompressed and re-expanded, corresponding with a discharge of one of the pump tanks.

The principle of operation is simple. Compressed air is admitted to a tank filled with water, or any fluid, forcing the fluid out through a check valve and pipe line, and at the same time the compressor is drawing air from the other tank, the charge of air being regulated so that when a tank is empty, the other is full, at which time the switch reverses, thereby reversing the action of the tanks.

The cycle of operation will be better understood by referring to Fig. 2; A and B are twin displacement tanks, preferably completely submerged, though they operate if so placed as to

be filled by siphon action.  $A'$  and  $B'$  are the two air pipe lines.  $C'$  and  $C''$  are discharge check valves preventing the return of the fluid ejected.

$D'$  and  $D''$  are check valves preventing the discharge of the fluid through the inlet.  $E$  is the discharge pipe from both tanks.

$F$  is the automatic switch controlling the pumping cycle.  $G'$  and  $G''$  are the tank risers.

$H$  is the compressing cylinder of an air compressor.  $J$  is the automatic compensating valve which keeps the system supplied with air.

In the diagram as shown, air is being withdrawn by the compressor  $H$  from the tank  $B$  and is being compressed in tank  $A$ . At the same time the fluid is entering the tank  $B$  through check valve  $D'$ , while it is being forced from the tank  $A$  through the riser  $G'$ , the check valve  $C'$  and the discharge pipe  $E$ .

The mathematical analysis of the system is difficult. Any one interested in a full discussion of the problem will find it fully brought out by Prof. Elmo G. Harris in Vol. 54 of the *Transactions of the American Society of Civil Engineers*.

In order to proportion a plant correctly, the needed data are as follows:

$Q_w$  = the quantity of water to be pumped in cubic feet per second.

$h$  = the total lift, or head, in feet.

$l$  = the total length of air pipes, the distance from compressor to pump tanks.

Having these, we must compute:

$Q_a$  = the volumetric capacity of the compressor, or the piston displacement in cubic feet per second.

$V$  = the volume of each pump tank (cubic feet).

$d$  = the diameter of air pipe (in inches).

$D$  = the diameter of water pipe (in inches).

$H. P.$  = the maximum horse-power required of the steam end of compressor.

From the formula:

$$Q_a = Q_w [1 + 1.4 \log_e R]$$

the following Table I has been prepared, showing the size of compressor, pipes, etc., required for various heads, based on 100 gal. of water per minute; for other quantities, the dimensions will be directly proportional. The table assumes the pump tanks to be fully submerged.

#### Air-Lift System.

The air-lift system of pumping, measured on the power basis, is not an efficient method of raising water, but where it is and can be applied, it fills a certain field and in that class of work does service that no other pump can do, and does it in a most satisfactory way. This method of pumping has been most generally applied to raising water from artesian wells. There are not many underground formations in which wells can be located close together without affecting each other when pumping, and for that reason it is best to spread them out on a line of what we call the line of underground flow.

Some formations are so tight that wells have but little capacity, and in such formations it is particularly necessary that the wells should be scattered and pumped moderately. For the reason that separate pumping units entail high first cost and labor for attendance, the air-lift system is recommended. An economical

TABLE I.—DIMENSIONS FOR RETURN-AIR SYSTEM.

Lift in feet.	Capacity of compressor in cu. ft. per minute piston displacement for 100 gals. per minute.	Max. I.H. P. of air cylinder.	Max I.H.P. of steam cylinder.	Average H.P. of steam cylinder.	Area of air pipe in sq. in. for each 100 gal. capacity of plant.	Area of water pipe in sq. in. for each 100 gal. capacity of plant.
50	39.84	2.74	3.22	2.80	0.96	7.70
60	42.78	3.28	3.85	3.37	1.03	8.25
70	45.30	3.85	4.53	3.93	1.09	8.73
80	47.70	4.45	5.22	4.49	1.14	9.12
90	49.80	5.03	5.91	5.05	1.20	9.60
100	51.84	5.67	6.67	5.61	1.25	10.00
110	53.64	6.31	7.43	6.17	1.29	10.30
120	55.44	6.96	8.18	6.73	1.33	10.60
130	57.00	7.62	8.97	7.29	1.37	10.95
140	58.50	8.30	9.75	7.85	1.41	11.30
150	59.94	9.00	10.60	8.41	1.44	11.50
160	61.38	9.75	11.45	8.98	1.47	11.75
170	62.64	10.42	12.25	9.54	1.50	12.00
180	63.84	11.13	13.08	10.10	1.53	12.25
190	64.98	11.85	13.95	10.66	1.55	12.40
200	66.12	12.76	15.00	11.22	1.58	12.65
210	67.20	13.35	15.70	11.78	1.62	12.95
220	68.28	14.09	16.60	12.34	1.64	13.10
230	69.24	14.92	17.35	12.90	1.67	13.35
240	70.20	15.68	18.45	13.46	1.69	13.50
250	71.10	16.46	19.35	14.02	1.71	13.70
260	72.00	17.24	20.25	14.58	1.73	13.82
270	72.84	18.00	21.20	15.14	1.75	14.00
280	73.56	18.80	22.10	15.71	1.77	14.20
290	74.28	19.60	23.10	16.27	1.79	14.30
300	75.06	20.45	24.00	16.83	1.80	14.40

central pumping station will serve any number of wells, compressed air being capable of transmission in proper sized pipes for great distances without serious loss.

The required equipment consists of an air compressor located at some convenient point, preferably in some existing power station where it can take advantage of economical steam conditions, an air receiver, and a pipe line leading from the receiver to the well or wells. The pump proper consists of nothing more than two plain pipes, one for air and one for water; these pipes run down inside of the well and are submerged for a certain depth proportionate to the lift when the pump is at work. Fig. 3 shows the different methods of piping wells. All wells are no alike, therefore it is a spec-

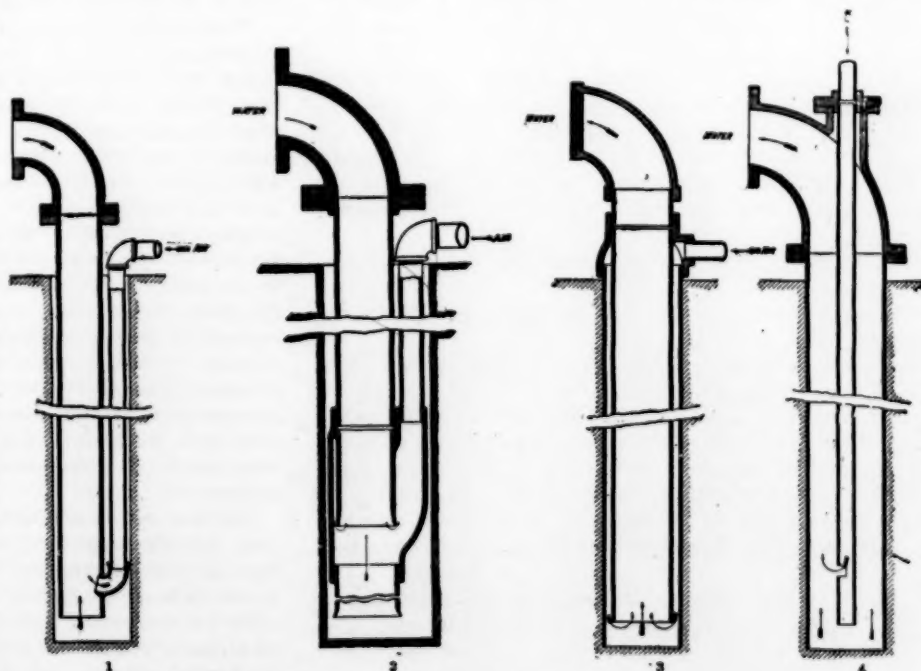


FIG. 3.—DIFFERENT METHODS OF PIPING WELLS.

problem in every case to determine the size and arrangement best suited.

Each method here shown has its use, depending upon the diameter and depth of the well, whether the well is cased or not, the lift, volume of water to be pumped, and character of



the water-bearing strata. The arrangement most generally used, where conditions permit, is shown in No. 1, Fig. 3. This is the Pohle or "side-inlet" method, in which the discharge and air pipes are placed side by side in the well, joined by a suitable foot-piece.

In No. 2, Fig. 3, compressed air fills the annular space surrounding the up-take pipe and is free to enter the rising column at all points of its periphery, at the same time acting without obstructing or contracting the discharge pipe anywhere.

Fig. 4 shows the tubular foot-piece. This device aims to provide a means for actually dividing air into fine streams, which we have found to be the best condition in which air can be introduced into the rising main. Air from the supply pipe fills the hollow base of the foot-piece. The base-plate is studded with  $\frac{1}{4}$ -in. wrought-iron pipes about 18 in. long extending upwards to a point where the water passes from the foot-piece into the discharge pipe, at which juncture the bubbles of air are released. Ample space is provided for the inflow of water to the foot-piece through the bottom openings, augmented by the larger side inlets shown. Thus we have in the foot-piece designed for a 5-in. discharge pipe a subdivision of air into thirteen  $\frac{1}{4}$ -in. streams, with the added advantage that these separate small pipes will tend to act as governors to control the discharge of the air.

The usual capacities allowed for the side-inlet method are as follows:

Air Pipe Connection.	Water Pipe.	Size Well.	Maximum Economical Capacity on Moderate lift.
			Gal. per min.
$\frac{1}{2}$ in. ....	1 in. ....	3 in. ....	7
$\frac{3}{4}$ " ....	$1\frac{1}{2}$ " ....	4 " ....	20
1 " ....	2 " ....	$4\frac{1}{2}$ " ....	35
1 " ....	$2\frac{1}{2}$ " ....	5 " ....	60
$1\frac{1}{4}$ " ....	3 " ....	6 " ....	100
$1\frac{1}{2}$ " ....	$3\frac{1}{2}$ " ....	7 " ....	140
$1\frac{3}{4}$ " ....	4 " ....	8 " ....	190
$1\frac{1}{2}$ " ....	5 " ....	9 " ....	250
2 " ....	6 " ....	10 " ....	350

No. 3, Fig. 3, shows the Sounders system. A central discharge pipe is suspended in the well, the air passing down between it and the well casing. If the well is not cased a second pipe must be used outside of the main discharge pipe, the air, as before, filling the annular space between the two pipes. In estimating pipes under this system it is usual to allow capacities as follows:

Lift, 25 ft., 15 to 20 gal. per minute per square inch area water pipe.

Lift, 50 to 125 ft., 12 to 15 gal. per minute per square inch area water pipe.

No. 4, Fig. 3, is the so-called "central air pipe" system. This method is generally used where the lift is low, and to obtain the greatest possible output from what are termed "strong wells," i. e., wells having a strong static pressure and finding their supply in gravel or open rock formations. The air pipe is suspended in the well without the usual discharge pipe. The proper sized air pipe for different sizes of casing and capacities are about as follows, depending upon the lift and submergence:

Size of Casing	Size of Air Pipe.	Capacity. Gal. per min.
$3\frac{1}{2}$ in. ....	$1\frac{1}{4}$ in. ....	80 to 100
4 " ....	$1\frac{1}{2}$ " ....	100 to 150
5 " ....	2 " ....	150 to 250
6 " ....	2 " ....	275 to 375
8 " ....	$2\frac{1}{2}$ " ....	500 to 665
10 " ....	$2\frac{1}{2}$ " ....	775 to 1000

Notwithstanding the fact that the air-lift system has been in commercial use for nearly 20 years and thousands of plants are in daily operation all over the world, no mathematically correct

formulas have been published covering the design of these pumps, nor is there exact information at hand for calculating the volume of air and pressure required to operate them under all conditions. This is due to a number of variable factors which enter into each proposition, and if we are to undertake to derive a practical working formula we must assume certain efficiencies for the system, and assume also that the wells will be properly piped to meet the proper relation of submergence to lift.

Although impossible to construct a formula which can be applied uniformly to all conditions met in this class of work, yet, as Mr. Abrams points out, we can define the trend and introduce certain rules which will permit any engineer to calculate the requirements for any given proposition when the exact data covering the case are known. The data required and the factors entering into these calculations may be reduced to the following:

$V_a$  = free air piston displacement required to raise 1 gal. water.

$h$  = total vertical lift in feet.

$H$  = submergence in feet.

$C$  = constant (efficiency of the system).

Before proceeding, the symbols above written must be clearly understood.

$V_a$  is the free air (piston displacement of the compressor) required to raise 1 gal. of water, due allowance having been made for the ordinary volumetric efficiency of the air compressor. If the compressors are in bad shape or poorly designed, of course, more displacement will be required from such a machine than from a well-designed compressor in good working order.

By "lift" is meant the total vertical lift from the pumping level of the water in the well to point of discharge.

"Submergence" is the depth the air pipe is submerged below the pumping level of the water in the well, and is an important factor in any installation; the percentage of submergence, so often heard of, is the percentage of the total length of pipe which is submerged in the solid water when pumping. The necessary percentage of submergence varies in accordance with the lift; low lifts require proportionally more submergence than high lifts; or, in other words, the necessary submergence decreases as the lift increases. The range of these percentages lies within the following limits: For lift of 20 ft., 66 per cent; for lift of 500 ft., 41 per cent. The average best percentage in the class of work usually encountered will lie between 50 and 65 per cent. Submergence also governs the pressure required, both the starting pressure and the working pressure. The air-lift differs from other pumps in that the pressure necessary to raise the column of water does not depend upon the head,  $h$ , but upon the submergence,  $H$ , or, in other words,  $H$  is the actual head against which the air pressure acts.

The first step in a calculation of this kind is to determine from the lift what the proper submergence should be, and knowing this submergence, the work can be easily calculated on the basis,  $P = 0.44 H$ .

We are now ready to calculate the air volume required (free-air piston displacement) to raise 1 gal. of water. The following formula may be used, which closely approximates average practice (in part suggested by Mr. Edward A. Rix):

$$V_a = \frac{h}{C \log \frac{H + 34}{34}}$$



FIG. 4.—TUBULAR FOOT PIECE.

The annexed table also shows the value of  $C$  calculated from the efficiency of the system under various heads, with proper submergence.

TABLE FOR VALUE OF  $C$ .

$h = \text{Lift.}$	$C = \text{Constant.}$
10 ft. to 60 ft.....	245
61 ft. to 200 ft.....	233
201 ft. to 500 ft.....	216
501 ft. to 650 ft.....	185
651 ft. to 750 ft.....	156

*Problem.*—Given a bore-hole, well, or shaft 250 ft. deep, the water in which stands 50 ft. below the ground surface, but which falls 25 ft. when being pumped at the rate of 200 gal. per minute, and it is required to raise the water 25 ft. above the ground:

Standing water level in well, measured from surface.... 50 ft.  
Drop when pumped ..... 25 ft.  
Elevation above surface to raise water..... 25 ft.

Total lift ..... 100 ft.

If the best ratio of submergence for a lift of 10 ft. is 58 per cent, then

$$H = \frac{h \times 0.58}{100 - 58} \text{ or } \frac{100 \times 0.58}{100 - 58} = 138 \text{ ft.}$$

and applying our formula,

$$V_a = \frac{100}{138 + 34} \times \frac{233}{C \log \frac{100}{34}}$$

and further introducing the value of  $C$  from the table, we have

$$V_a = \frac{100}{233 \times 0.704151} = 0.60.$$

$V_a = 0.60$  cu. ft. (piston displacement) per gallon of water; hence for 200 gal.  $200 \times 0.60 = 120$  cu. ft. will be required.

The next calculation is to find the starting and the working pressure. Observe that the normal or standing water level is 25 ft. higher than the working, which indicates a submergence at the beginning of operations equivalent to  $138 + 25 = 163$  ft. The starting pressure must be just sufficient to overcome that due to the height of the water column above the footpiece.

$$163 \times 0.44 = 72 \text{ lb. gage, the starting pressure.}$$

$$0.44 H = 138 \times 0.44 = 61 \text{ lb., the working pressure.}$$

The actual pumping level in a well or group of wells can seldom be known in advance of a test. It is customary to assume certain conditions of lift and submergence, basing such conclusions on experience, and proceed to pipe the wells accordingly. After the piping is installed and the working conditions arrived at, the submergence is altered to suit by raising or lowering the pipe in the well until the best ratio is established.

The quantity of water a well will yield depends upon its diameter and the natural flow. It is also essential that the pipes both for air and water be properly proportioned, for the reason that velocity of flow is an important factor; if too large a pipe is used the air gets through without doing all the work it should, and, on the other hand, if the velocity is too high there is undue friction loss and also inefficient expansion of the air bubbles. The best results are ordinarily obtained by providing for a discharge of 12 to 15 gal. per square inch area of discharge pipe.

Tables are available for determining the friction loss of air pipes. It is, of course, essential to keep this loss within reasonable limits. The flow should not exceed 1500 ft. per minute.

One reason why the air-lift has been so popular, aside from its flexibility and simplicity, is the fact that the yield of a well is frequently increased by its use. Wells can be cleaned of sand, keeping open the water-bearing seams. As there is little apparatus in the well, an unobstructed flow is assured. The

air-lift will handle all the water a well yields, but if a given well is equal, at its maximum, to a flow of 50 gal. per minute the air-lift has so miraculous power whereby the yield can be increased.

Water is also purified and improved by the intimate commingling with air on its passage through the discharge pipe. There is a complete aeration as the water flows upward, putting it in condition to throw off sulphur gas, precipitate iron, and in a measure prevent vegetable growth.

#### SPECIAL USES FOR THE AIR-LIFT.

The pumping of oil wells offers a superior opportunity for the air-lift, and in this line of work compressed air has been pre-eminently satisfactory. One of the advantages possessed by the air-lift, whether it be in pumping water or oil, is the ability of the system to handle sand and gritty matter.

On account of the facility with which the air-lift, owing to the fact that no working parts come in contact with material being pumped, can handle sand, mud, and other substances destructive to ordinary mechanical pumps, it is an ideal method for pumping in the following cases:

1. Slimes, a mixture of water and the very fine portions of crushed ore coming from a reduction plant.
2. Sand and water for stone saws. All preparation necessary for work of this kind is a "master" well or pit sunk to a proper depth to provide the necessary submergence.
3. The air-lift has done excellent work as a dredge pump and if its usefulness along these lines were better appreciated we should see a great many more installations. The arrangement of air-lift units on a scow, with proper facilities for raising and lowering the pipes, presents unexcelled features of simplicity and capacity.
4. Agitation of slimes in the cyanide process also offers an opportunity for the air-lift, as complete and satisfactory aeration can be brought about by placing an air-lift in a cyanide tank specially designed for the purpose.

The air-lift is past the experimental stage and is taking its place with other applications of compressed air where steady, reliable results are appreciated.

#### Personal

**Dr. Frederick G. Cottrell**, of San Francisco, who is in charge of metallurgical investigations of the Bureau of Mines, visited metallurgical plants in Denver, Leadville, Salt Lake City and Ely on his return west from New York and Washington.

**Mr. W. G. Swart**, Western representative of the American Zinc Ore Separating Company, with headquarters at Denver, has gone to Europe on professional business. He will be absent about two months.

**Mr. T. A. Rickard**, of London, spent a few days in Denver on his return to London from San Francisco. He was entertained at a dinner given by local engineers.

**Mr. Bernard MacDonald**, of Guanajuato, Mexico, was in Denver recently.

**Mr. L. H. Norton**, of Silverton, Col., has returned after spending a few months in Mexico.

**Mr. R. M. Henderson**, manager of the Wellington Mines at Breckenridge, Col., who has been in the hospital in Denver for several months following an accident received at Breckenridge, has returned to his work.

**Dr. Erich A. Beck**, metallurgist of the Goldschmidt Thermit Company, New York, recently spent two weeks in Colorado on business for his company. He expects to visit Germany this summer.

**Mr. Russel Raynolds** has been transferred from the Durango plant (Colorado) of the American Smelting & Refining Co., to the Globe plant (Denver), where he will have charge of the research laboratory. **Mr. J. E. Bonsack**, formerly in charge of the latter laboratory, has been transferred to New York.



### Digest of Electrochemical U. S. Patents

Prior to 1903.

*Arranged according to subject-matter and in chronological order.*

*Compiled by Byrnes, Townsend & Brickenstein, Patent Lawyers, National Union Building, Washington, D. C.*

#### ORE TREATMENT (Continued).

544,610, Aug. 13, 1895, Edward W. Clark, of Butte, Montana, assignor of two-thirds to Edwin M. Clark and The Western Iron Works, of same place.

Relates to the extraction of gold from ores by the chlorination method. The ore is suitably pulverized and mixed with a solution of chlorid of sodium and placed in a cylindrical vat containing rotary stirrers. Within the vat is an anode preferably of carbon, and mercury cathodes are placed in a rectangular vessel, outside of the vat, and communicating therewith by perforations in the cylindrical vat. An electric current is then passed through the solution, chlorine and oxygen being generated at the anode, and it is brought into intimate contact with the ore by the stirrers. The stirrers further have a spiral arrangement which tends to gradually propel the ore to the exit where it is discharged into a second cylinder. After treatment, the mercury is gathered, and the gold removed therefrom.

546,873, Sept. 24, 1895, Edgar Arthur Ashcroft, of Broken Hill, New South Wales.

Relates to the leaching of ores of the Broken Hill type of sulfids. The ore is first roasted and then leached with a solution containing a ferric salt which extracts the zinc oxid and precipitates ferric hydrate. When the leaching is complete, the solution and residues are separated by settling or otherwise, and the residues briquetted with quicklime, for subsequent smelting. The solution containing zinc also may contain silver, gold, copper and other metals which may then be precipitated by the action of metallic zinc applied in the well known manner. The solution, having been freed from interfering metals, is electrolyzed in a cell and the zinc recovered. During electrolysis the zinc is removed and iron added to the solution from iron anodes. The solution is again electrolyzed in another compartment, using carbon anodes, where the ferrous salts present are oxidized to ferric salts. The latter ferric solution is then available for leaching fresh ore. Lead salts present may be converted into lead chlorid by a similar reaction and the lead chlorid subsequently converted into an insoluble sulfate by the addition of sodium sulfate or by any zinc sulfate resulting from the oxidation of the zinc sulfid in the original ore. The lead sulfate will precipitate and may be smelted with the residues obtained from the leaching process.

549,907, Nov. 19, 1895, Alfred L. Eltonhead, of Philadelphia, Pennsylvania.

Relates to the extraction of gold and other metals from ores by the cyanid process. The finely crushed ore or tailings having been leached with a solution of cyanid, the latter is electrolyzed in a rectangular cell, passing through the cathode compartment by a tortuous route. The bottom of the cell is covered with mercury and connected as a cathode. A central compartment of the cell comprises the anode compartment and contains a solution of potassium carbonate or other alkaline carbonate. An anode in the potassium carbonate decomposes the latter, forming potassium or sodium amalgam. The potassium or sodium amalgam reacts with a solution of potassium cyanid in the tortuous cathode compartment, separating the gold by substitution, forming potassium cyanid and gold amalgam. An electrical current of low voltage and high amperage is passed through the potassium carbonate to the mercury. The reformed potassium cyanid may be used in the subsequent extraction of ore. At suitable intervals, the gold amalgam is collected from the mercury cathode and separated in a well known manner.

### BOOK REVIEWS.

**L'Argent et les Métaux de la Mine de Platine.** By M. Molinié and H. Dietz. 12mo, 399 pages, 93 illustrations; price 5 francs. Paris: Octave Doin et Fils.

A large amount of information for a small amount of money. The metallurgy of silver is a good condensation of the subject, brought pretty well up-to-date. Worthy of special mention are five chapters on "silver in industry," in which are described at length the manufacture of alloys, coins, jewelry, plate, wire, foil, the uses of silver salts, and the recovery of silver from industrial residues. Platinum is satisfactorily handled in 75 pages, and palladium is fairly treated, but iridium is given only one page, and rhodium, osmium and ruthenium barely mentioned. The book is well worth its cost to anyone interested in silver or the platinum metals.

\* \* \*

**Der Kautschuk und seine Prüfung.** By Prof. Dr. F. W. Hinrichsen and Dipl. Ing. K. Memmler. 263 pages, 64 illustrations. Price Marks 8. Leipzig: S. H. Hirzel.

As far as the reviewer knows there are but few places in the world where such unique facilities for scientific investigations and tests exist, combined with liberal contributions from practical experience on the part of manufacturers as is the case with the "Kge. Material Prüfungsamt" at Gross-Lichterfelde, near Berlin. Both authors are members of this institution and as the "Prüfungsamt" keeps in closest touch with all industrial problems, no one was better prepared than the authors to write this book. The authors have made the best of their opportunity and are to be congratulated on their success.

The industrial and scientific knowledge of caoutchouc have rapidly increased during recent years. The synthetical and analytical work of Harries Willstaetter and Fritz Hofmann have brought about the artificial production of caoutchouc and although it has so far not been utilized on a commercial scale, the applications of caoutchouc for all kinds of industrial purposes are broadening at such a rate that the results of scientific progress in this field must be of general interest.

Dr. Hinrichsen himself has studied the vulcanization of caoutchouc, applying the methods of physical chemistry to this problem, and has also extended the methods of the analytical determination of its natural and intentionally added constituents. Mr. Memmler deserves much credit for improving and, in fact, redesigning the methods of physical tests of this material.

The book consists of three parts. The first deals with history, properties, chemical constitution and artificial ingredients, theory of vulcanizing, properties of vulcanized india rubber, and manufacture of india rubber materials. The second part deals extensively with the chemical analysis of the raw material before and after vulcanizing and with the examination of the products after continued use. The third part which occupies over a hundred pages of the book, contains an interesting description of experiments and the results of a great many determinations of physical properties which can not be enumerated in detail. Especially this part reflects the genial spirit of A. Martens, the originator of many of the physical testing apparatus used in the material Prüfungsamt. The good illustrations given in the book increase the value of the descriptions.

All three parts contain many literature references. The book as a whole is an excellent introduction into the chemistry and physics of the manufacture of caoutchouc. It should also prove interesting reading for every consumer who wants to familiarize himself with the properties of this material and the latest investigations concerning its preparation. The reviewer enjoyed last summer a personal introduction by both of the authors into their exhaustive work and remembers with pleasure seeing many of the apparatus described in this book in practical and successful use.